Form 1276A

TB Wood's

S-TRAC™

LST

Solid-State Starter

User's Manual

TB WOOD'S INCORPORATED
Chambersburg, Pennsylvania

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Section 1: Introduction

1.1 Product Overview

The LST Solid-State Starter is another member of the S-trAC™ family of soft-start controllers. It is microprocessor-based, and provides start and stop control as well as motor protection. Models arrive from the factory with NEMA 1 / IP23 protection, although the enclosure extension may be removed to provide IP00 protection — thus making the LST starter suitable for mounting in another enclosure. (See Appendix B on page 69 for information on removing the enclosure extension.)

In operation, LST models provide:

- Improved soft-start and soft-stop of motor and load.
- Reduced starting current.
- Motor thermal modeling.
- Phase sequence, phase loss, electronic shearpin, and motor thermistor protection.

In addition, installation, commissioning, and maintenance are simplified by the LST starter's many other sophisticated functions which enhance performance and reliability, and which make the equipment suitable for optimizing nearly all motor starting applications. These functions include:

- Automatic analysis and configuration of motor connection, phase sequence, supply voltage, and frequency.
- Uni-Start soft-start.
- Current Limiting.
- Trip output (Form C contacts).
- Line contactor control.
- Bypass contactor control.
- Uni-Stop soft stop.
- Simple, accurate, and repeatable programming procedures.
- Diagnostic fault display.

1.2 Models Currently Available

A wide range of LST Solid-State Starter models are currently available. The models range from 13 to 372 amps for 200 to 600 Vac. Section 2.1 on page 3 provides more information about the models by detailing the information contained in the model number.

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1.3 Scope of This Manual

This manual contains specifications, receiving and installation instructions, configuration, description of operation, and trouble-shooting procedures for the LST Solid-State Starter.

1.4 Related Documentation

The following documentation is also available for other members of the S-trAC line of soft-start controllers:

- Form 1232 (HST Solid-State Starter)
- Form 1233 (IST Soft Start Controller)
- Form 1255A (SOFTRON Soft Start Controller)
- Form 1257 (DST Solid-State Starter)

1.5 Publication History

Date	Nature of Change
October 1998	Pre-release version (Form 1276).
December 1998	First edition (Form 1276A).

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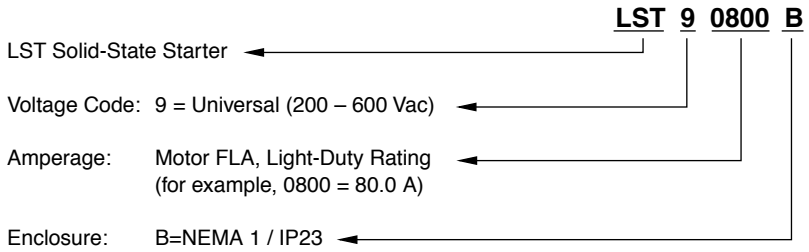
Section 2: Technical Characteristics

2.1 Interpreting Model Numbers

The model number of the LST Solid-State Starter appears on the shipping carton label and on the technical data label affixed to the model. The information provided by the model number is shown below:


LST 9 0800 B
LST Solid-State Starter
Voltage Code: 9 = Universal (200 – 600 Vac)
Amperage: Motor FLA, Light-Duty Rating
(for example, 0800 = 80.0 A)
Enclosure: B=NEMA 1 / IP23

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2.2 General Specifications

Power circuit	Reverse parallel connected thyristors
Input voltage	200 to 600 Vac (3-phase)
Input frequency	50 Hz ±2 Hz; 60 Hz ±2 Hz
Control voltage	115 V (–15%, +10%) or 230 V (–15%, +10%)
Current rating	See Section 2.3 on the next page
Motor connection	3-wire
Digital inputs	• 24 Vdc, approximately 8 mAdc • Use contacts that are low voltage, low current rated (for example, Gold Flash) • Quantity: 5 (Start, Stop, Reset, Auxiliary Trip Input, Local/Remote))
Relay outputs	• Contacts rated for 5 A @ 250 Vac/360 VA or 5 A @ 30 Vdc resistive • Quantity: 3 (Run [Form A], Main Contactor Control [Form A], Trip [Form C])
Degree of protection	NEMA 1 / IP23 with cover and wiring gland in place IP00 without enclosure extension (see Appendix B)
Ambient temperature	Operating: 0 °C to 45 °C (32 °F to 113 °F) Storage: –5 °C to 65 °C (–23 °F to 149 °F)
Relative humidity	5 to 95% maximum non-condensing
Protective features	• Prestart motor circuit check • Prestart input frequency range check • Prestart input voltage range • Prestart phase loss protection • Phase sequence protection
Agency Listings	• Certified to CAN/CSA C22.2 No. 14 (Conforms to Industrial Control Equipment Component Only) • ETL Listed • CE Marked

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2.3 Current Ratings

2.3.1 Continuous Operation

Table 1: 60% Duty Cycle (Off Time = 145 seconds), 10 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	13	12	12	12	9	8
LST90250B	25	24	23	22	17	16
LST90340B	34	33	31	30	23	22
LST90390B	39	37	36	34	26	25
LST90550B	55	53	53	51	37	35
LST90730B	73	69	69	66	48	46
LST90800B	80	77	76	72	53	51
LST91260B	126	120	114	108	82	78
LST91360B	136	130	124	118	88	84
LST91580B	158	151	152	145	106	101
LST91930B	193	185	184	177	130	124
LST92230B	223	213	212	204	149	143
LST92640B	264	255	251	242	176	170
LST93720B	372	355	344	328	243	231

Table 2: 70% Duty Cycle (Off Time = 108 seconds), 10 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	12	12	12	11	9	8
LST90250B	24	23	23	22	16	16
LST90340B	33	31	30	28	22	21
LST90390B	37	35	34	32	25	24
LST90550B	55	52	52	50	37	35
LST90730B	71	68	68	64	48	45
LST90800B	79	75	74	71	53	50
LST91260B	121	115	110	104	80	76
LST91360B	131	125	120	114	86	82
LST91580B	156	149	150	143	105	100
LST91930B	190	183	182	175	129	124
LST92230B	219	210	210	201	148	142
LST92640B	260	251	248	239	175	168
LST93720B	362	346	336	321	239	228

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Table 3: 80% Duty Cycle (Off Time = 73 seconds), 10 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	12	12	12	11	8	8
LST90250B	24	22	22	21	16	15
LST90340B	31	29	28	27	21	20
LST90390B	36	34	33	31	24	23
LST90550B	54	51	52	49	36	35
LST90730B	70	66	66	63	47	45
LST90800B	77	73	73	70	52	49
LST91260B	115	110	105	100	78	74
LST91360B	126	120	116	110	84	80
LST91580B	154	147	148	142	104	99
LST91930B	188	180	180	173	128	123
LST92230B	217	208	207	198	146	140
LST92640B	256	246	244	235	173	167
LST93720B	352	335	328	312	235	224

Table 4: 90% Duty Cycle (Off Time = 35 seconds), 10 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	12	11	11	11	8	8
LST90250B	23	22	21	20	16	15
LST90340B	29	28	27	26	21	20
LST90390B	34	32	31	30	24	23
LST90550B	53	50	51	48	36	34
LST90730B	68	65	65	62	46	44
LST90800B	75	71	71	68	51	49
LST91260B	109	104	101	96	75	71
LST91360B	120	115	111	106	82	78
LST91580B	151	144	146	139	103	98
LST91930B	185	178	178	171	127	121
LST92230B	213	203	204	196	145	138
LST92640B	251	242	240	231	171	165
LST93720B	340	324	318	303	230	219

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2.3.2 Bypassed Operation

Table 5: 2.5 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	14	14	14	13	10	9
LST90250B	31	30	29	28	20	19
LST90340B	47	45	44	42	30	29
LST90390B	52	50	48	46	33	32
LST90550B	59	56	57	54	39	37
LST90730B	79	76	75	72	52	49
LST90800B	88	84	83	80	57	55
LST91260B	160	153	144	138	99	95
LST91360B	160	153	145	139	100	95
LST91580B	166	159	160	153	110	195
LST91930B	202	194	194	187	135	139
LST92230B	237	227	226	218	157	150
LST92640B	282	272	269	259	186	179
LST93720B	418	400	387	370	266	254

Table 6: 10 Starts per Hour

Model	Light Duty 300% FLC for 10 sec		Medium Duty 300% FLC for 30 sec		Heavy Duty 450% FLC for 30 sec	
	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)	40°C (104°F) (A)	45°C (113°F) (A)
LST90130B	14	14	13	13	9	9
LST90250B	30	29	27	26	18	18
LST90340B	45	43	39	37	26	25
LST90390B	50	47	43	41	30	28
LST90550B	59	56	56	53	38	37
LST90730B	79	75	73	70	50	48
LST90800B	87	83	81	77	56	53
LST91260B	155	148	133	127	91	87
LST91360B	157	150	138	132	95	90
LST91580B	165	158	158	151	108	104
LST91930B	201	193	191	184	133	127
LST92230B	235	226	222	213	153	147
LST92640B	280	270	263	254	182	175
LST93720B	413	395	373	357	256	245

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2.4 Dimensions

Figures 1 and 2 on the following pages show the dimensions of the LST Solid-State Starter models. NEMA 1/IP23 protection is standard and is achieved by an enclosure extension that encloses the LST starter's terminals. A model may be made suitable for mounting in another enclosure (IP00 protection) by removing the enclosure extension. See Appendix B on page 69 for the dimensions once the enclosure extension is removed.

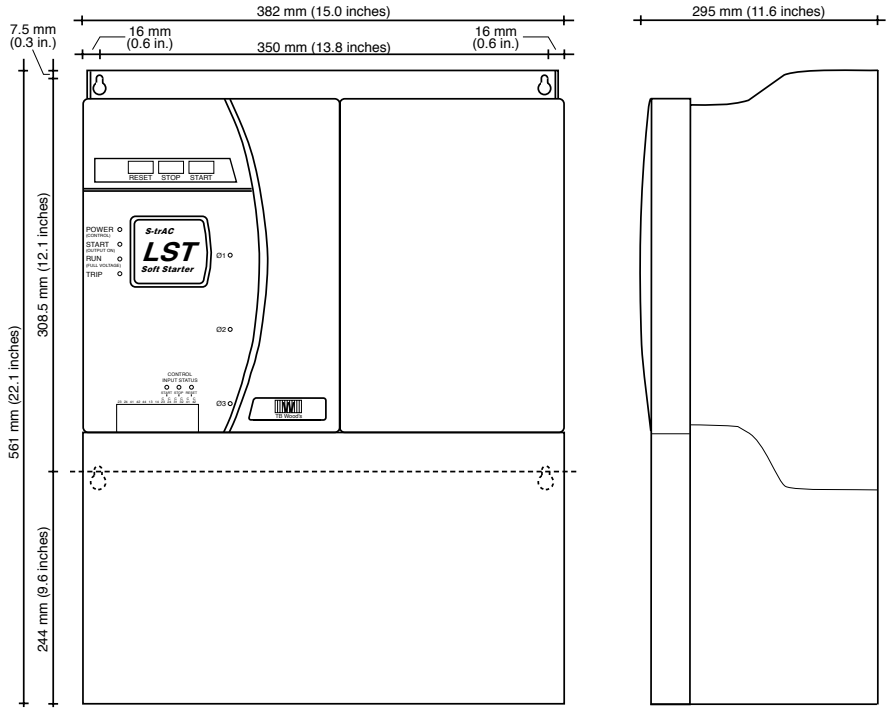

Figure 1: LST Models Rated 158 Amps or Greater

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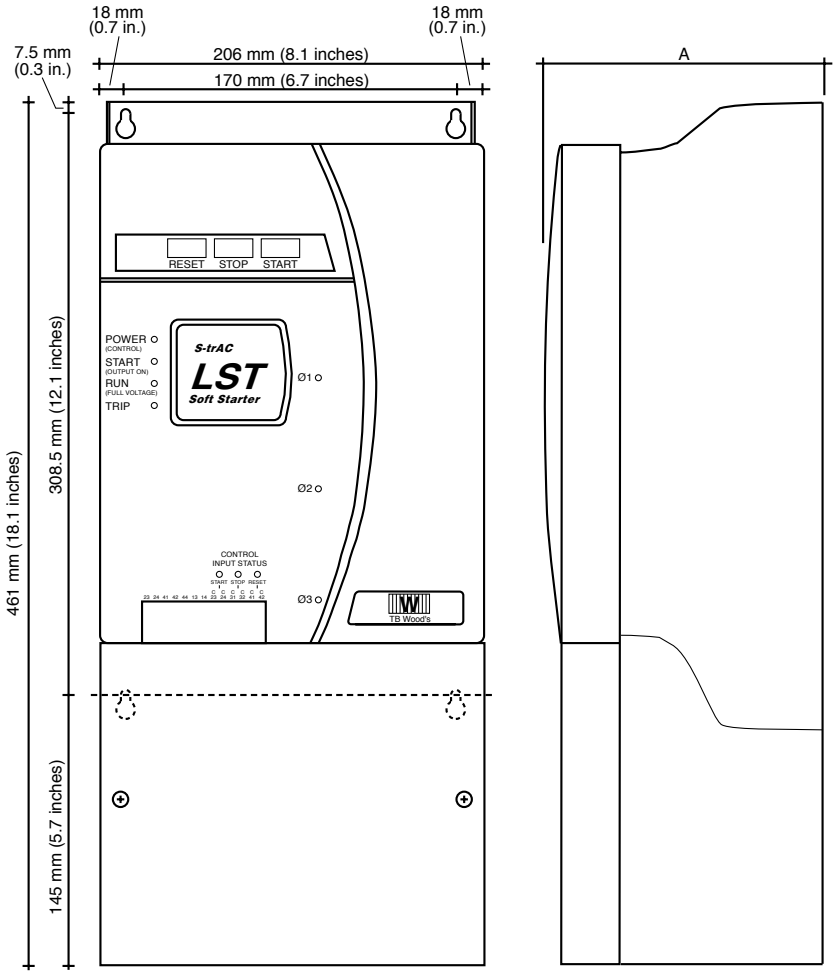

LST Model	Dimension "A" mm (inches)
LST90130B, LST90250B, LST90340B, LST9039B	180 (7.1)
LST90550B, LST90730B, LST90800B, LST91260B, LST91360B	250 (9.8)

Figure 2: LST Models Rated 136 Amps or Less

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2.5 Weights

The following table shows the weights of the LST models.

Model	Weight		Model	Weight	
	Kg	Lbs		Kg	Lbs
LST90130B	7	15.5	LST91260B	12	26.5
LST90250B	7	15.5	LST91360B	12	26.5
LST90340B	7	15.5	LST91580B	21	46.4
LST90390B	7	15.5	LST91930B	21	46.4
LST90550B	11	24.3	LST92230B	22	48.6
LST90730B	11	24.3	LST92640B	23	50.8
LST90800B	11	24.3	LST93720B	23	50.8

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Section 3: Features

3.1 Introduction

Figure 3 shows the LST Solid-State Starter with the LED indicators and terminal connections labeled. Other than the DIP switch, these items are described in this section; the DIP switch is discussed in Section 7 starting on page 47.

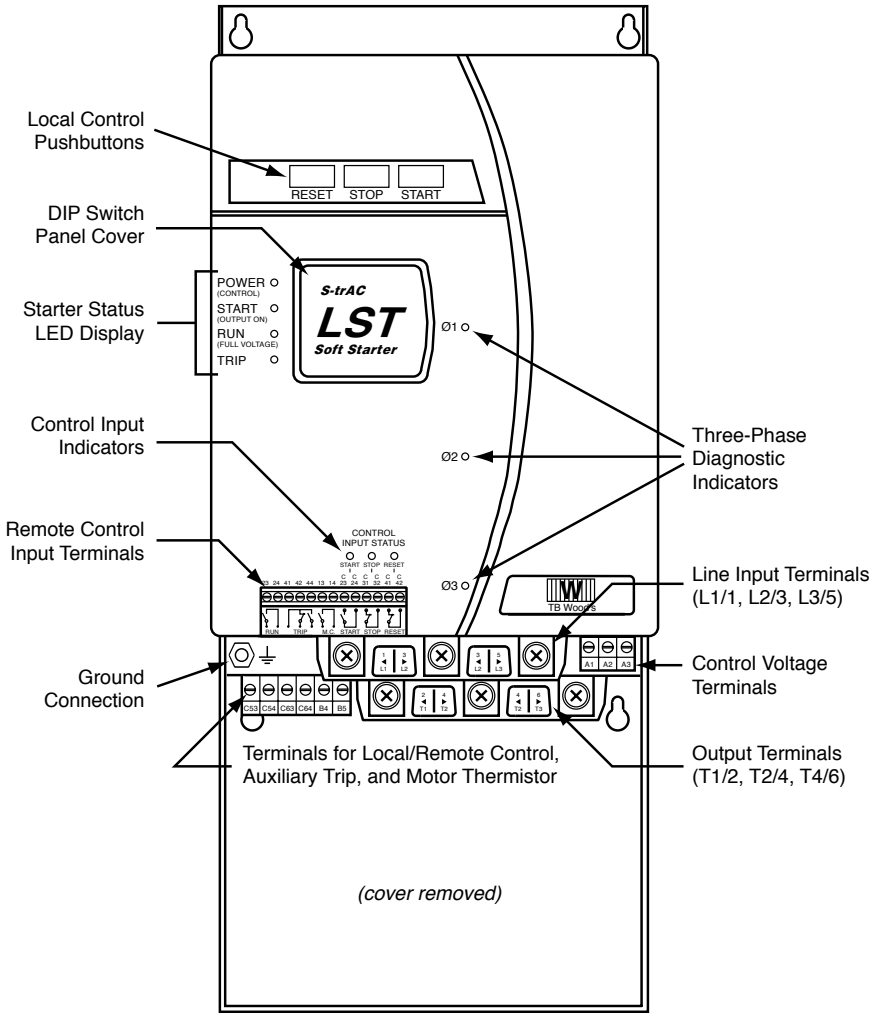

Figure 3: LST Starter LED Indicators and Terminal Connections

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3.2 Local Control Pushbuttons

Towards the top of the LST starter are three pushbuttons. These pushbuttons provide local control for Start, Stop, and Reset functions. Their operation is not indicated by the control input LED indicators located near the remote control input terminals. Terminals C63 and C64 may be used to switch between local and remote control.

3.3 LED Indicators

3.3.1 Status Indicators

Four LED indicators provide information on the operation of the LST starter. These indicators provide the following information:

- **Power** (yellow): Control voltage is present.
- **Start** (green): The LST starter is supplying voltage to the output, and the Main Contactor (M.C.) relay is closed. The starter may be in the Soft Start, Run, or Soft Stop modes.
- **Run** (green): The LST starter is supplying full output voltage, and the Run relay is closed.
- **Trip** (red): The LST starter has tripped, and the Trip relay has operated. A manual reset is required to restore operation. The LED will flash multiple times in quick succession, and then pause and repeat, to indicate a particular fault; see the Troubleshooting section starting on page 51 for more information.

3.3.2 Remote Control Input Indicators

Three LED indicators provide information on the status of the remote Start, Stop, and Reset inputs. Note that they do not indicate the status of the local Start, Stop, and Reset pushbuttons. The following information is provided by the remote control input indicators:

- **Start** (yellow): The remote Start input is closed.
- **Stop** (yellow): The remote Stop input is closed.
- **Reset** (yellow): The remote Reset input is closed.

3.3.3 Three-Phase Diagnostic Indicators

Three LED indicators provide phase information. Each LED indicates the voltage differential between the input and output voltage on each phase of the LST starter.

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Under normal conditions, all three LEDs will be lit with equal intensity when the starter is Off and will gradually dim as the output voltage increases during a start. The LEDs will be completely extinguished when the starter is delivering full output voltage.

Under abnormal conditions, the indicators may appear as follows:

- If the output voltage is not present on a phase or if the output has an open circuit on a phase, the LED for that phase will not be lit (while the other LEDs will be lit).
- If the voltage is low on one phase, one or more LEDs will be lit dimly.
- If an SCR has a failed short circuit, the corresponding LED will not be lit (while the other LEDs will be lit).

See page 51 for more detailed information on using the LEDs to diagnose and correct abnormal conditions.

3.4 Terminals

The LST starter has five groups of terminals, as shown in Figure 3 on page 11, along with the Ground terminal:

- Line input terminals (L1/1, L2/3, L3/5)
- Output terminals (T1/2, T2/4, T3/6)
- Control voltage terminals (A1, A2, A3)
- Control terminals (in two groups)

These terminals will be discussed in greater detail in Section 5 starting on page 23.

3.5 Protective Features

The LST starter incorporates several protective features. These are described in the following sections.

3.5.1 Auto-Configuration

LST starters automatically determine the motor connection, supply frequency, supply voltage, and phase sequence. They also configure internal parameters for correct operation. If a problem is detected, the LST starter inhibits operation.

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3.5.2 Prestart Circuit Analysis and Configuration

LST starters also perform a series of automatic system tests (prestart circuit analysis and configuration) to prevent damage from incorrect installation or supply problems. Tests include:

- Motor and supply circuits
- Motor connection configuration
- Frequency range
- Voltage range
- Phase sequence

Upon successful completion of the tests, voltage is applied to the motor. The starter will perform up to three prestart checks before tripping due to failure of any of the prestart checks. See Figure 4 for relay operation during prestart circuit analysis and configuration.

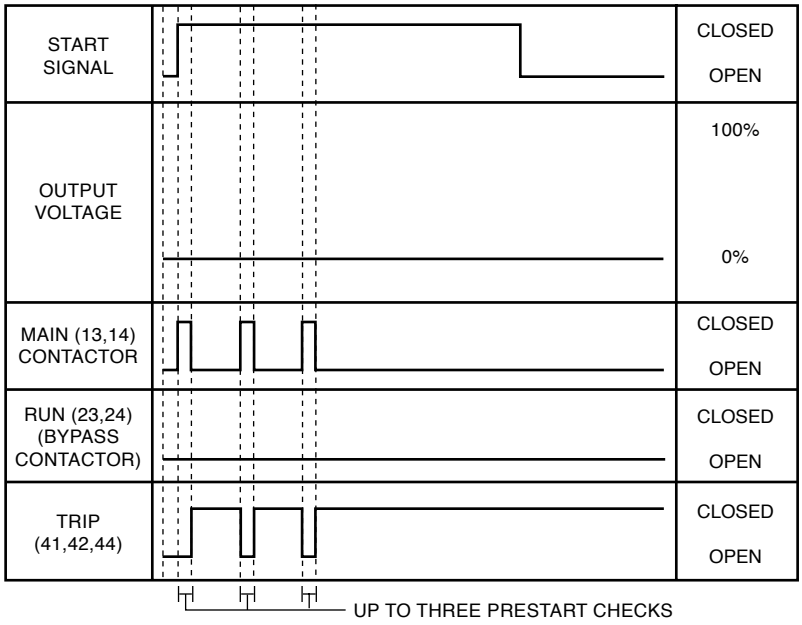

Figure 4: Relay Operation During Prestart Circuit Analysis and Configuration

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3.5.3 Phase Loss and Phase Sequence Protection

LST starters provide phase loss protection as well as optional phase sequence protection.

With phase loss protection, if a phase is lost either before or during operation, the starter will trip and turn off. The sensitivity of the protection is automatically reduced during starting and stopping to accommodate the discontinuous waveform. If necessary, the sensitivity may be further customized by using the Phase Loss potentiometer; see page 49 for further information on this potentiometer.

In addition to phase loss protection (which is always active), you may also choose to utilize phase sequence protection. This type of protection guards against damage from reverse motor rotation caused by incorrect phase sequence of the incoming electrical supply. The starter will trip and turn off if an incorrect phase sequence is detected. Phase sequence protection is turned on or off via the DIP switch; see page 48 for more information.

3.5.4 Electronic Shearpin Protection

LST starters incorporate electronic shearpin protection. This protection may be used to detect changes in motor loading that may indicate that the motor is about to jam — thereby allowing the starter to trip before the motor, drive chain, and/or machine is damaged.

With this protection, if the motor exceeds a preprogrammed maximum current, the starter will trip and turn off. The default setting is for the protection to be enabled once the motor reaches full speed and operates at 300% FLC. However, this is adjustable via the Electronic Shearpin potentiometer. See page 49 for information on how to access and adjust this potentiometer.

3.5.5 Motor Overload Protection

Advanced motor overload protection is provided by the utilization of a thermal model for motor temperature.

The connected motor's FLC is entered into this model, and then the model continually calculates motor temperature — even when the motor is not running. This ensures good protection while still enabling the motor to work to its maximum capacity during both start and overload conditions. If necessary, you may adjust the sensitivity of this

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model with the Thermal Model potentiometer. See page 49 for information on how to access and adjust this potentiometer.

When commissioning, or re-commissioning after the removal of control voltage from the starter, verify that the motor is cold before starting the motor to ensure accurate thermal modeling.

The thermal model is compromised if the motor is operated outside of its specification (for example, ambient temperature in excess of rated ambient or motor cooling fan is blocked or inoperative). Motor thermistor protection should be used to detect abnormal conditions.

3.5.6 Thermistor Protection

PTC motor thermistors, if fitted in the motor, may be directly connected to terminals B4 and B5 of an LST starter. (If motor thermistors are not connected, terminals B4 and B5 should be connected together by a jumper. LST starters are shipped from the factory with a jumper in place.) The thermistor circuit should be run in screened cable and must be electronically isolated from earth and all other power and control circuits. The threshold resistance is 1800 Ω, and the thermistor current is less than 1.5 mA.

3.5.7 Auxiliary Trip Protection

Terminals C53 and C54 may be used to connect a device (such as an undercurrent relay, low-level probes, or vibration switches) to remotely-trip the LST starter. This simplifies control circuitry since the starter functions as the sole point of connection for any external control circuitry.

3.6 The Uni-Start Feature

Uni-Start is an advanced method of control used by LST starters to generate a controlled-current soft start. In this method, motor starting current is raised to an Initial Start Current and then ramped up to the customer-established Start Current Limit. The current then remains at the Start Current Limit until full speed is approached, and then falls to Run current levels. Figure 5 on the next page provides a graphical representation of a typical soft-start.

A key element of Uni-Start is that it dynamically adjusts starter output to match the motor characteristics as they change during starting and stopping. (Uni-Start is operative in both start and stop modes.) This

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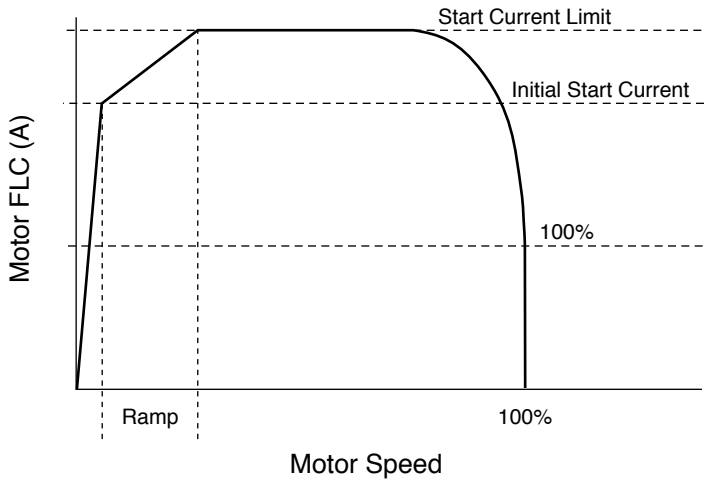

Figure 5: Typical Soft-Start with an LST Starter

eliminates the motor instability sometimes experienced with ordinary soft-start systems. Uni-Start provides particular advantage in pumping applications where both starting and stopping times can be adjusted to minimize fluid hammer without the need for dedicated "pump start" models.

The DIP switch is used to set the Start Current Limit and the motor FLC; see page 48 for further information. The required setting for the Start Current Limit is installation-dependent and should be set such that:

1. At a minimum, the motor-supplied start current should be sufficient to enable it to produce an adequate torque to easily start the connected load; and
2. Desired starting performance is obtained.

Note that setting the DIP switch to the appropriate values should produce satisfactory performance for nearly all applications. However, potentiometers are available for the ramp time and Initial Start Current to further refine and customize the soft-start. See page 49 for further information on the potentiometers.

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3.7 The Uni-Stop Feature

In addition to the Uni-Start feature, LST starters also provide an optional Uni-Stop feature. This feature dynamically adjusts starter output to match the motor characteristics as they change during stopping, which eliminates the motor instability sometimes experienced with ordinary soft-start and soft-stop systems. Uni-Stop provides particular advantage in pumping applications where both starting and stopping times can be adjusted to minimize fluid hammer without the need for dedicated "pump start" models.

Uni-Stop is activated by setting the DIP switch to a value between 2 and 62 seconds for the soft-stop ramp time; see page 47 for further information on the DIP switch. When enabled, this feature reduces the voltage applied to the motor, causing the motor to stall and decelerate to zero speed. The effect of this is to add inertia to the load, thereby reducing the rate of deceleration. Figure 6 below provides a graphical representation of a typical Uni-Stop soft stop.

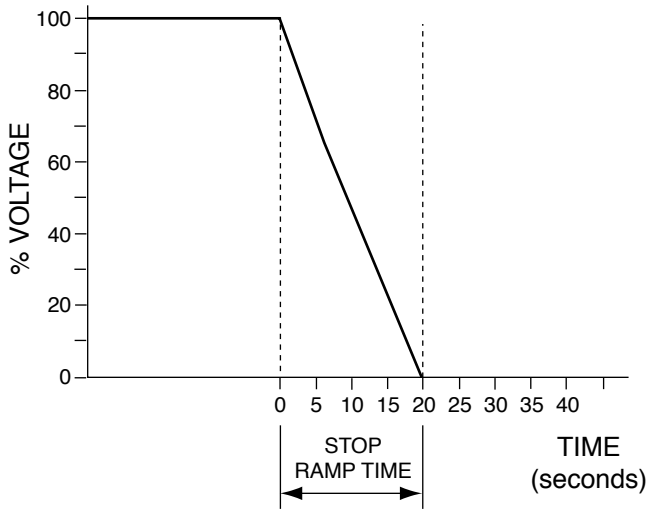

Figure 6: Typical Soft-Stop with an LST Starter

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Section 4: Receiving and Installation

4.1 Handling

⚠ WARNING

HANDLING HAZARD

Keep the area below any equipment being lifted clear of all personnel and property.

Failure to observe this instruction can result in death, serious injury, or equipment damage.

⚠ AVERTISSEMENT

RISQUE LORS DE LA MANUTENTION

Assurez-vous qu'il n'y a personne ni matériel sous l'appareil en train d'être levé.

Si ces précautions ne sont pas respectées, cela peut entraîner la mort, des blessures graves ou des dommages matériels.

Do not remove the LST Solid-State Starter from its packaging until it is at the final installation site. The LST starter is packaged to be protected from the hazards of shipping, and is best protected in its original shipping packaging.

4.2 Preliminary Inspection

Before storing or installing the LST starter, thoroughly inspect the device for possible shipping damage. Upon receipt:

1. Remove the starter from its package and inspect the exterior for shipping damage. If damage is apparent, notify the shipping agent and your sales representative.
2. Remove the cover and inspect the starter for any apparent damage or foreign objects. Ensure that all mounting hardware and terminal connection hardware is properly seated, securely fastened, and undamaged.
3. Read the technical data label affixed to the starter and ensure that the correct horsepower and input voltage for the application was purchased.
4. If you will be storing the starter after receipt, place it in its original packaging and store in a clean, dry place free from direct sunlight or corrosive fumes, where the ambient temperature is not less than -5 °C (23 °F) or greater than +65 °C (+149 °F).

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⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Do not operate or install any LST starter that appears damaged.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

Ne faites pas fonctionner et n'installez pas tout onduleur qui semble être endommagé.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

4.3 Mounting Precautions

Improper installation of the LST Solid-State Starter will greatly reduce its life. Be sure to observe the following precautions when selecting a mounting location. ***Failure to observe these precautions may void the warranty!***

1. Do not install the starter in a place subjected to high temperature, high humidity, or excessive vibration.
2. Do not mount the starter near heat radiating elements or in direct sunlight.
3. Mount the starter vertically.
4. Do not obstruct cooling airflow.
5. The starter generates heat. Allow sufficient space around the unit for heat dissipation. See Figure 7 for required minimum clearances.

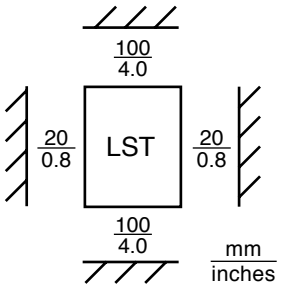

Figure 7: Minimum Clearances

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4.4 Mounting in Ventilated Enclosures

When mounting an LST starter, sufficient airflow through the enclosure must be present to prevent excessive heat build-up. Figure 8 provides representations of typical ventilated enclosures.

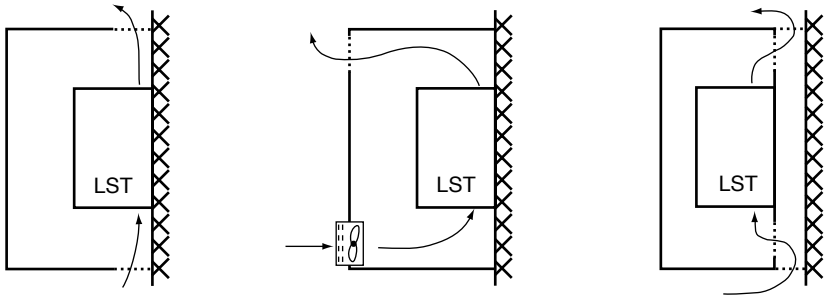

Figure 8: Typical Ventilated Enclosures

Soft starters dissipate approximately 4.5 watts per line amp. The table on the following page shows the airflow required to limit internal temperature rise of an enclosure to +5 or +10 °C (+9 or +18 °F). Note that if additional heat sources are also housed in the enclosure, the airflow will need to be increased accordingly.

Table 7: Minimum Airflow Requirements to Limit Heat Rise

Motor Amps	Heat Dissipation (watts)	Airflow (ft^3/min) Required to Limit to:	
		5 °C (9 °F) Rise	10 °C (18 °F) Rise
10	45	17.7	7.1
20	90	31.8	17.7
30	135	49.5	24.7
40	180	63.6	31.8
50	225	81.2	38.8
75	338	120.1	60.0
100	450	158.9	81.2
125	563	197.8	98.9
150	675	240.2	120.1
175	788	279.0	137.7
200	900	317.9	158.9
250	1125	399.1	197.8
300	1350	476.8	240.2
350	1575	558.1	279.0
400	1800	635.8	317.9
450	2025	717.0	356.7
500	2250	794.7	399.1
550	2475	875.9	438.0
600	2700	953.6	476.8

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4.5 Mounting in Non-Ventilated Enclosures

If the LST starter is to be in a non-ventilated enclosure, a bypass contactor should be used to eliminate heat build-up.

The bypass contactor can be AC1 rated (inrush less than 2.5 times the Full Load Current) as it only carries the running current of the motor. The bypass contactor should be controlled by the Run output (terminals 23 and 24), and should be used to bypass the SCRs once the motor has started by bridging between:

L1/1-T1/2, L2/3-T2/4, L3/5-T3/6 **or** 1-2, 3-4, 5-6

See Figure 12 on page 27 for a wiring diagram.

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

- The bypass contactor must connect L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6. An y other combination will cause fuse failure, circuit breaker trip, and possible SCR failure.
- To maintain the motor protection features of the LST starter during bypassed operation, the internal CTs must be removed and mounted in the enclosure extension so they measure line current. See Appendix A on page 61 for the removal and re-mounting procedure.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

- Le contacteur de dérivation doit relier L1/1 à T1/2, L2/3 à T2/4 et L3/5 à T3/6. Toute autre combinaison entraînera le bris du fusible, le déclenchement du disjoncteur ou possiblement le bris du SCR.
- Pour préserver les particularités de protection du moteur du démarreur LST durant la dérivation, les TC internes doivent être enlevés et montés dans la rallonge de l'armoire pour mesurer le courant du secteur. Consultez la procédure d'enlèvement et de remontage à l'annexe A de la page 61.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

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Section 5: Connections

5.1 Introduction

This chapter describes the power circuit and control circuit connections for the LST Solid-State Starter. Figure 9 below provides the electrical connection diagram for the starter.

Note that the LST starter is shipped from the factory without the gland plate attached to the enclosure extension. Since all power and control

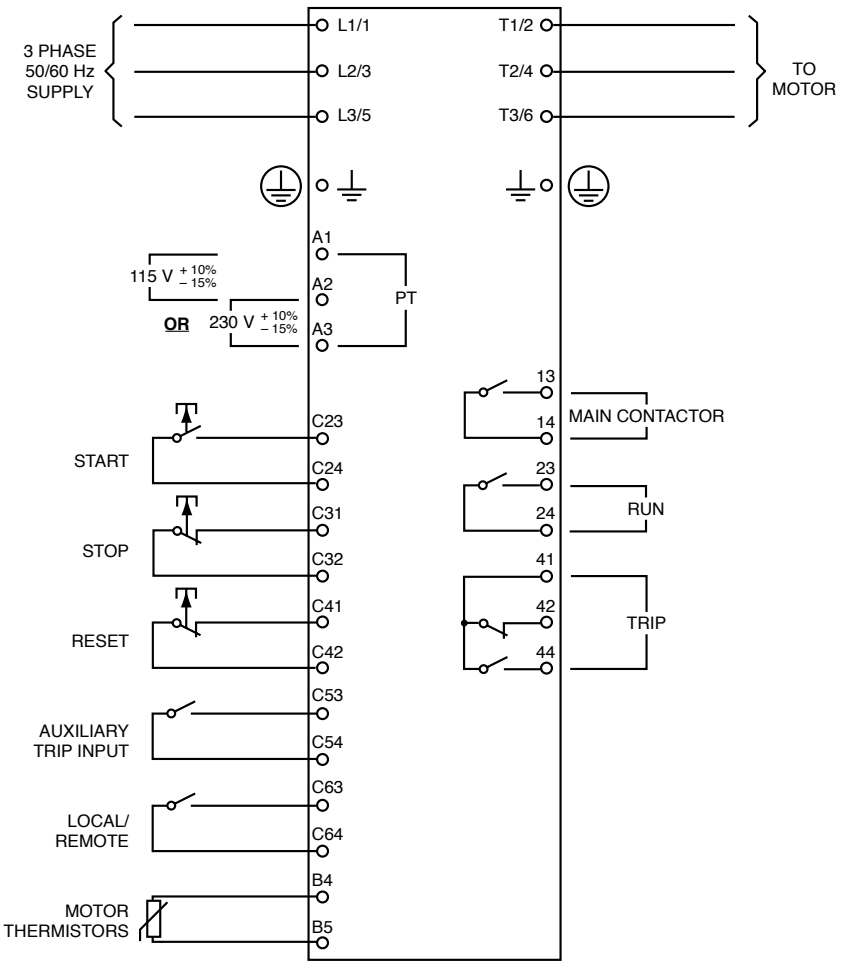

Figure 9: LST Starter Electrical Connection Diagram

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wiring must pass through the gland plate, **attach the gland plate before making any wiring connections**. The gland plate attaches to the bottom of the enclosure extension using four of the screws provided (the other two screws are for attaching the cover). After attaching the gland plate, remove the appropriate knock-outs to run the power and control wiring through the gland plate.

5.2 Power Connections

The power connections are L1/1, L2/3, and L3/5 for input mains connection and T1/2, T2/4, and T3/6 for motor connection.

5.3 Fuse Selection

Fast-acting semiconductor fuses should be used with the LST starter to reduce the potential of damage. The recommended supplier is Bussman, although equivalent values from other manufacturers may be substituted. Use the following table to select the appropriate fuses for each LST model.

Table 8: Fuse Selection Table

Model Number	Fuse	Number Required
LST90130B	FWP-40B	1 per phase
LST90250B	FWB-125B	1 per phase
LST90340B	FWB-125B	1 per phase
LST90390B	FWB-150A	1 per phase
LST90550B	FWB-150A	1 per phase
LST90730B	FWP-200A	1 per phase
LST90800B	FWP-300A	1 per phase
LST91260B	FWP-400A	1 per phase
LST91360B	FWP-400A	1 per phase
LST91580B	FWP-400A	1 per phase
LST91930B	FWP-450A	1 per phase
LST92230B	FWP-450A	1 per phase
LST92640B	FWP-450A	1 per phase
LST93720B	FWP-600A	1 per phase

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5.4 Motor Connection

The LST Solid-State Starter may be configured in a number of circuit configurations. Figure 10 below illustrates a three-wire motor connection, while Figure 11 shows that the starter may be connected to motors designed for Wye or Delta operation (if the motor is appropriate for the supply voltage).

5.4.1 Line Contactors

The LST starter is designed to be operated with or without a line contactor. If a line contactor is used, then the starter's SCRs will be isolated when they are most susceptible to damage from voltage transients by being placed in the Off state. The LST starter can directly control a line contactor via the Main Contactor (M.C.) control output (terminals 13 and 14).

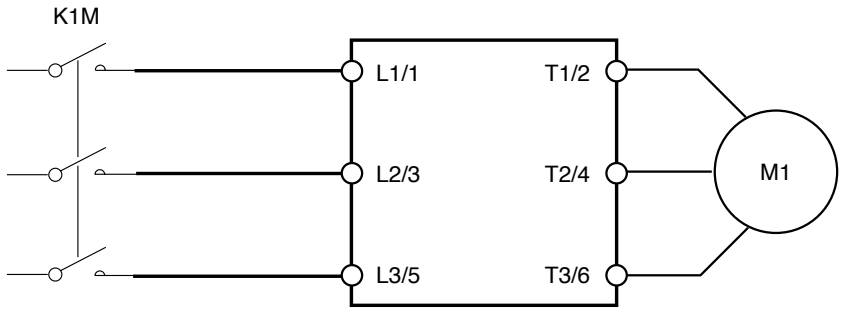

Figure 10: Three-Wire Motor Connection

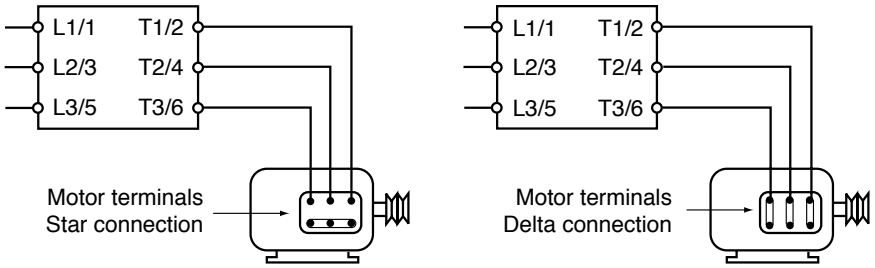

Figure 11: Wye and Delta Connections

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Alternatives to a line contactor are an undervoltage trip circuit breaker operated by the starter's Trip output (terminals 41, 42, and 43), or a motor-operated circuit breaker. If a motor-operated circuit breaker is used as a line contactor, the potential delay between the breaker being signaled to close and phase power being applied to the LST starter could cause the starter to trip on installation faults. This may be avoided by closing the motorized breaker directly and using the breaker's auxiliary contacts to control the LSTstarter.

5.4.2 Bypass Contactors

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

- The bypass contactor must connect L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6. An y other combination will cause fuse failure, circuit breaker trip, and possible SCR failure.
- To maintain the motor protection features of the LST starter during bypassed operation, the internal CTs must be removed and mounted in the enclosure extension so they measure line current. See Appendix A on page 61 for the removal and re-mounting procedure.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

- French.
- French.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

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If the LST starter is to be mounted in a non-ventilated enclosure, a bypass contactor should be used to eliminate heat buildup in the enclosure. Figure 12 shows a typical wiring for a bypass contactor. The bypass contactor may be AC1 rated (inrush less than 2.5 times FLC) as it only carries the running current of the motor.

The bypass contactor should be controlled by the Run output (terminals 23 and 24), and should bypass the SCRs once the motor has started by bridging between terminals L1/1 – T1/2, L2/3 – T2/4, and L3/5 – T4/6.

Bypass contactors should be controlled to bypass the starter during Run mode. The digital output of the starter's bypass contactor should be used to control the bypass contactor.

If using a bypass contactor:

- Connect the bypass contactor between the starter's inputs and outputs, ensuring that with the contactor closed L1/1 connects to T1/2, L2/3 connects to T2/4, and L3/5 connects to T3/6.
- Connect the coil of the bypass contactor through the starter's Run relay outputs to the control voltage.

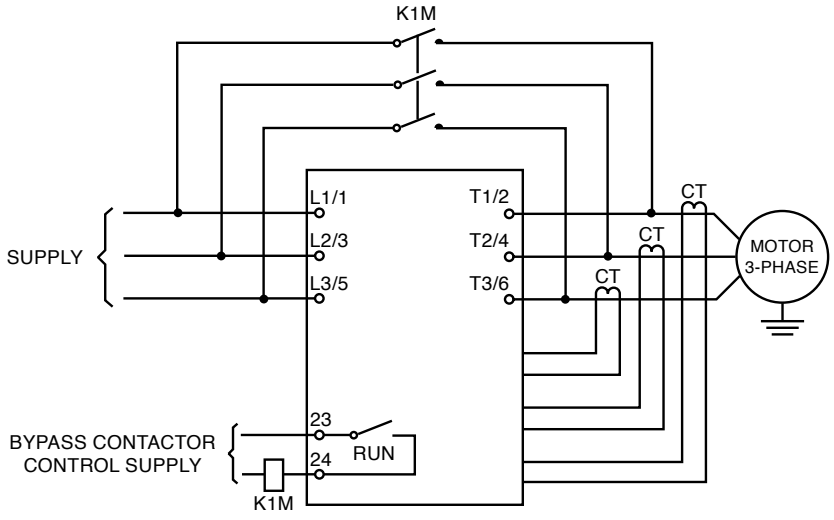

Figure 12: Typical Wiring for a Bypass Contactor

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5.4.3 Power Factor Correction

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Under no circumstances should power factor correction capacitors be connected between the LST Solid-State Starter and the motor.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

Les condensateurs de correction du facteur de puissance ne doivent jamais être raccordés entre le démarreur transistorisé LST et le moteur.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

If static power factor correction is used, it must be connected to the supply side of the LST starter. Ideally, power factor correction capacitors should be connected to the supply using a dedicated contactor which is energized once the motor has started.

Adding power factor correction capacitance to an inductive supply forms a resonant circuit. This resonant circuit can produce high ringing voltage that can damage the LST starter and other equipment connected to the same supply. Connecting power factor correction capacitors to the supply after the motor has started ensures the supply is loaded and dampens the ringing voltage.

This contact is controlled with the starter's Run relay (terminals 23 and 24) as shown in Figure 13 on the next page.

5.4.4 Phase Sequence

The supply may be connected to the LST starter in any phase sequence. However, the starter's Phase Sequence Protection feature may be used to prevent motor rotation in the reverse direction caused by a negative phase sequence.

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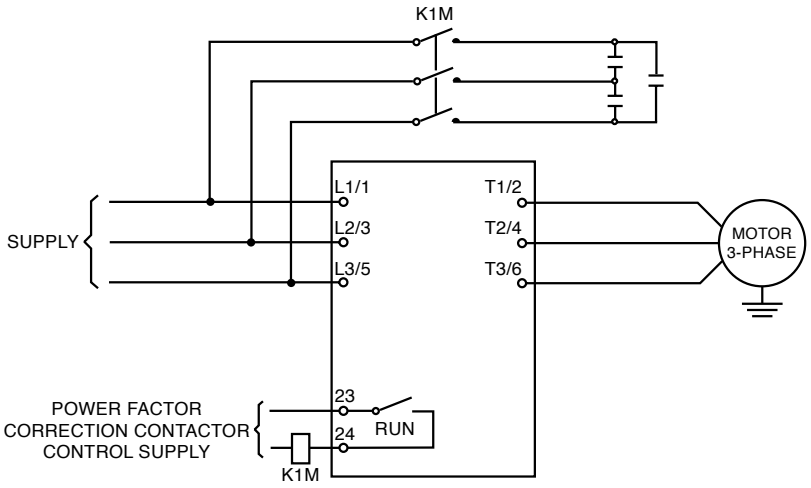

Figure 13: Power Factor Correction Wiring Diagram

5.5 Control Connections

5.5.1 Control Supply for Fans and Electronics

The LST starter must be supplied with control voltage which controls both the electronics and cooling fans (if fan-cooled). The control voltage terminals are located on the lower right side of the starter as shown in Figure 3 on page 11. Refer to the labeling on the starter for control voltage options, and Figure 14.

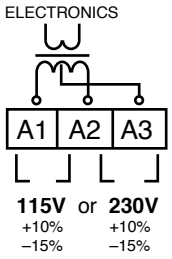

Figure 14: Control Voltage Options

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5.5.2 Digital Inputs

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Voltage must not be applied to the digital input terminals. Application of voltage is likely to cause equipment damage.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

Aucune tension ne doit pas être appliquée aux bornes d'entrée numérique. L'application de tension va probablement endommager l'appareil.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

The LST starter has five digital inputs: Start, Stop, Reset, Auxiliary Trip Input, and Local/Remote. Figure 3 on page 11 shows the location of the terminals for these inputs. Table 9 on the next page describes the digital inputs, while Table 10 on page 32 provides operational information for the inputs.

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Table 9: Digital Inputs for the LST Solid-State Starter

Inputs	Description
Start (C23, C24)	• Active 24 Vdc. • Hard contact circuit; close contacts between C23 and C24 to operate. **Four-Wire Control**: The start contact is closed momentarily to start the motor. The start signal is then latched internally by the starter until either the starter trips or the Stop circuit is opened (see below). **Two-Wire Control**: In a two-wire, non-latching circuit, the start input is shorted to +24 Vdc and the starter is controlled by closing and opening the Stop input. • Contacts used for controlling this input should be low voltage, low current rated (Gold Flash or similar).
Stop (C31, C32)	• Active 24 Vdc. • Hard contact circuit; close contacts between terminals C31 and C32 to activate. (Must be closed for the starter to operate.) • Contacts used for controlling this input should be low voltage, low current rated (Gold Flash or similar).
Reset (C41, C42)	• Active 24 Vdc. • Hard contact circuit; close contacts between terminals C41 and C42 to activate. (Must be closed for the starter to operate. Open circuit to closed circuit transition resets the starter.) • Contacts used for controlling this input should be low voltage, low current rated (Gold Flash or similar).
Auxiliary Trip Input (C53, C54)	• Active 24 Vdc. • Hard contact circuit; open contacts between terminals C53 and C54 to activate. (Must be open for the starter to operate.) • Contacts used for controlling this input should be low voltage, low current rated (Gold Flash or similar).
Local/Remote (C63, C64)	• Active 24 Vdc. • Hard contact circuit; close contacts between terminals C63 and C64 for remote control; open contacts for local control (via pushbuttons on the LST starter). • Contacts used for controlling this input should be low voltage, low current rated (Gold Flash or similar).

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Table 10: Overview of Operation of Digital Inputs

Off mode	In the Off mode, the starter's microprocessor monitors the Start, Stop, Reset, and keypad inputs. a. If the Reset input is an open circuit, the starter ignores all other inputs. b. If the Stop, Start, and Reset inputs are closed, the starter enters the Prestart mode. **Note:** The Start input is only monitored in the Off and Soft Stop modes.
Prestart mode	In the Prestart mode, the Main Contactor auxiliary is closed and the starter's microprocessor measures the supply frequency, motor connection, phase sequence, and the presence of all phases. Depending on the results of these measurements, the starter either auto-configures itself and enters the Start mode, or trips on an installation fault or phase sequence fault.
Start mode	In the Start mode, the starter's microprocessor monitors the Stop and Reset inputs. a. If the Stop input is open and Reset is closed, the starter enters the Soft Stop mode. b. If both Stop and Reset are open, the starter immediately stops and enters the Off mode. c. If the output voltage from the starter reaches full voltage, the starter enters the Run mode.
Run mode	In the Run mode, the starter's microprocessor monitors the Stop and Reset inputs. a. If the Stop input is open and Reset is closed, the starter enters the Soft Stop mode. b. If both Stop and Reset are open, the starter immediately stops and enters the Off mode.
Soft Stop mode	In the Soft Stop mode, the starter's microprocessor monitors the Start, Stop, and Reset inputs. a. If the stop time parameter is zero, the starter immediately enters the Off mode. b. If both Stop and Reset are open, the starter immediately stops and enters the Off mode. c. If both the Stop and Reset inputs are closed, the starter enters the Start mode. d. As the output voltage approaches zero, the starter enters the Off mode.
Trip mode	In Trip mode, the starter's microprocessor monitors the Reset input. In Trip mode, SCR conduction is inhibited. If the Reset input is closed, the starter enters the Off mode.

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5.5.3 Relay Outputs

The LST starter has three relay outputs:

- Run (Form A)
- Main Contactor Control (Form A)
- Trip (Form C).

Contacts are rated for 5 A @ 250 Vac/360 VA, or 5 A @ 30 Vdc resistive. Figure 3 on page 11 shows the location of the relay outputs. Table 11 below describes the relay outputs, and Table 12 on page 34 provides an overview of the operation of the outputs. Figure 15 on page 34 illustrates how the three relay outputs (Main Contactor [M.C.], Run, and Trip) behave during normal starter operation.

Table 11: Relay Outputs for the LST Starter

Relay Output	Description
Main Contactor (13, 14)	• Hard contact, normally-open relay contact. • Closes when the starter receives start signal. Opens when the starter stops applying voltage to the motor and when the starter trips. • Designed to control operation of a line contactor if connected on the input of the starter. This function is particularly useful when using the Soft Stop function and a line contactor, as it closes the contactor on start and opens the contactor at the end of the ramp-down period.
Run (23, 24)	• Hard contact, normally-open relay contact. • Closes when the starter is applying line voltage to the motor. • Designed to control a bypass contactor, if used, and/or as an Off-Load output for compressors, conveyors, pumps, etc.
Trip (41, 42, 44)	• Hard contact, Form C relay contacts. • Terminals 41 and 42 are closed in normal operation (terminals 41 and 44 are open). • Terminals 41 and 44 are closed when starter is tripped (terminals 41 and 42 are open).

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Table 12: Overview of the Operation of the Relay Outputs

Relay	Description
Off mode	In the Off mode, the Main Contactor, Run, and Trip relay outputs are in their normal state.
Prestart mode	In the Prestart mode, the Main Contactor is closed and the starter's microprocessor performs a number of measurements. Depending on the results of these, the starter either auto-configures itself and enters the Start mode or trips on an installation fault or phase sequence fault.
Start mode	In the Start mode, the Main Contactor is closed. If the output voltage from the starter reaches full voltage, the starter will enter the Run mode.
Run mode	In the Run mode, both the Main Contactor and the Run relays are closed.
Soft Stop mode	In the Soft Stop mode, the Run relay is open and the Main Contactor relay is closed. The output voltage is reduced at the rate determined by the stop time parameter (soft stop). a. If the stop time is zero, the starter immediately enters the Off mode. b. If the stop time is greater than zero, the starter enters the Off mode as the output voltage approaches zero.
Trip mode	In the Trip mode, the Main Contactor and Run relays are open and the Trip relay changes to the tripped state. SCR conduction is inhibited. If Reset is closed, the starter enters the Off mode.

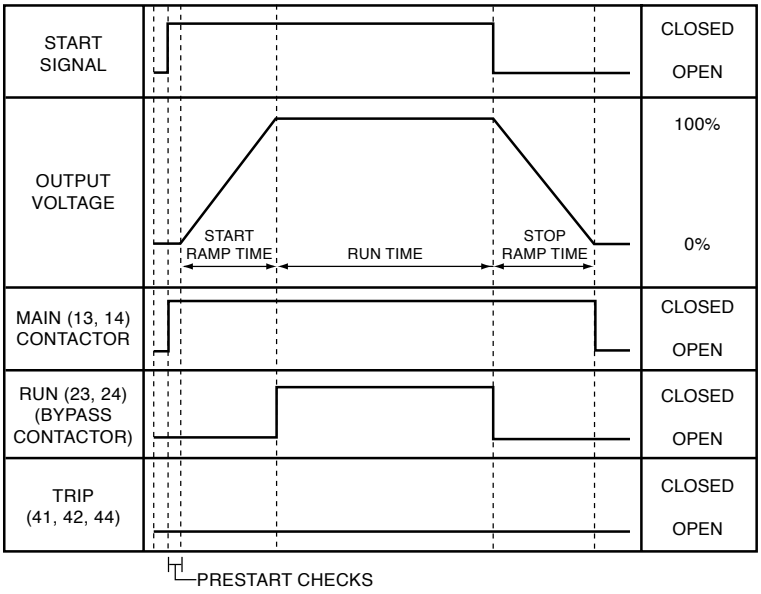

Figure 15: Relay Output Operation

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5.6 Sample Application Connections

LST starters may be connected and controlled in a variety of ways. Four common applications are illustrated in the examples on the following pages to assist you in developing an application that meets your particular requirements.

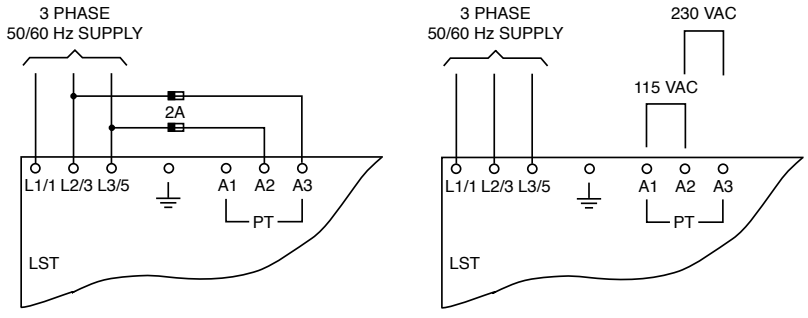
Note that the control voltage connection is not shown in these applications since the options for this are the same for each example. As discussed previously, the control voltage may be either 115 Vac (connected to terminals A1 and A2) or 230 Vac (connected to terminals A2 and A3). As a third option, the control voltage may be fed from incoming line power. Figure 16 shows these control voltage options.

5.6.1 Sample Application 1

This application is a stand-alone application where the LST starter is installed without any other circuitry and motor operation is controlled using the Start, Stop, Reset pushbuttons (local control). Figure 17 on the next page shows the wiring connections for this application.

Installation procedure:

1. Connect line voltage to the LST starter's terminals (L1/1, L2/3, L3/5).
2. Connect the motor to the starter's output terminals (T1/2, T2/4, T3/6).



Line-Fed Control Voltage

Independently-Fed Control Voltage

Figure 16: Control Voltage Options

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3. Connect the control voltage to the starter's PT input (control power) terminals; see Figure 16 on page 35.
4. The performance of the LST starter may be adjusted using the DIP switch. See page 47 for configuring the DIP switch and page 49 for fine-tuning the performance of the starter.

Notes:

- The motor may be started and stopped by using the pushbuttons on the top of the LST starter. Pressing the Start pushbutton initiates a start by causing the starter to apply power to the motor; pressing the Stop button causes the starter to initiate a stop (or soft-stop, if so configured).
- Trip states may be reset, and fault indication cleared, by pressing the Reset pushbutton on the starter or removing control voltage from the starter.

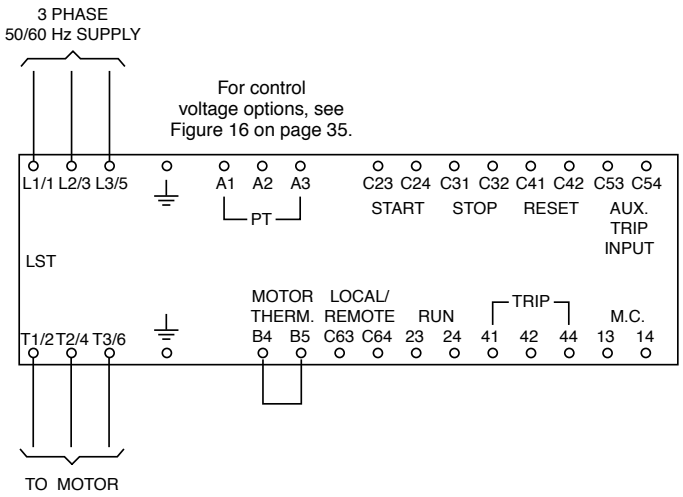

Figure 17: Wiring Connections for Sample Application 1

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5.6.2 Sample Application 2

This sample application is a typical application where the LST starter is controlled by remote Start, Stop, Reset pushbuttons and a line isolation contactor is used. (The local pushbuttons cannot be used in this application since the Local/Remote terminals are connected together via a jumper.) Figure 18 shows the wiring connections for this example.

Installation procedure:

1. Connect line voltage to the LST starter's terminals (L1/1, L2/3, L3/5) from the output terminals of an appropriate line contactor.
2. Connect the motor to the starter's output terminals (T1/2, T2/4, T3/6).
3. Connect the control voltage to the starter's PT input (control power) terminals; see Figure 16 on page 35.
4. Connect control circuitry as shown in Figure 18.

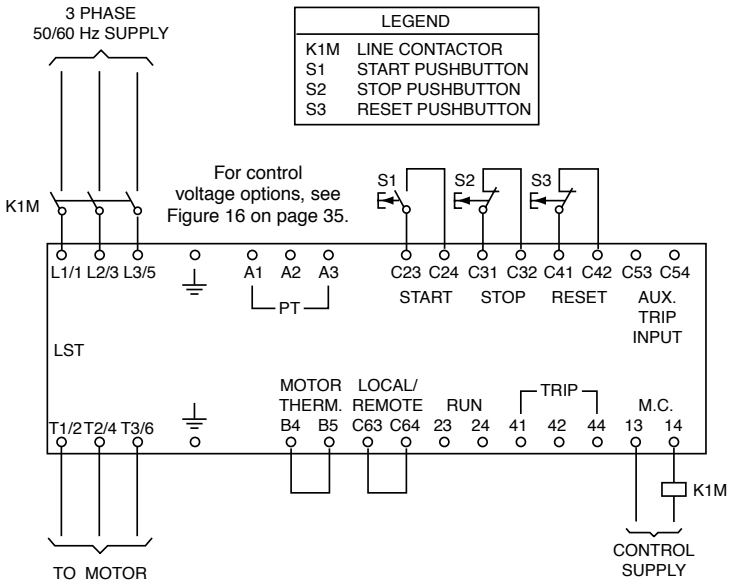

Figure 18: Wiring Connections for Sample Application 2

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5. The performance of the LST starter may be adjusted using the DIP switch. See page 47 for configuring the DIP switch and page 49 for fine-tuning the performance of the starter.

Notes:

- The LST starter is in the Remote Control mode. The motor may be started and stopped by using the remotely-located pushbuttons. Operating the Start pushbutton initiates a start by causing the starter to close the line contactor, which applies power to the motor; pressing the Stop button causes the starter to initiate a stop (or soft-stop, if so configured).
- Trip states may be reset, and fault indication cleared, by operating the remotely-located Reset pushbutton or removing control voltage from the starter.

5.6.3 Sample Application 3

In this sample application, the LST starter is controlled by a remote two-wire start circuit and is bypassed during run operation. Note that the starter's CTs were removed from within the unit and mounted externally to keep all protection features operative when the starter is bypassed. (See Appendix A for instructions on externally-mounting the starter's CTs.) Figure 19 on the next page provides the wiring connections for this sample application.

Installation procedure:

1. Connect line voltage to the LST starter's terminals (L1/1, L2/3, L3/5).
2. Connect the motor to the starter's output terminals (T1/2, T2/4, T3/6).
3. Connect the bypass contactor to bridge between L1/1 and T1/2, L2/3 and T2/4, and L3/5 and T3/6.
4. Connect the control voltage to the starter's PT input (control power) terminals; see Figure 16 on page 35.
5. Connect control circuitry as shown in Figure 19.
6. The performance of the LST starter may be adjusted using the DIP switch. See page 47 for configuring the DIP switch and page 49 for fine-tuning the performance of the starter.

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Notes:

- The motor may be started and stopped via the remote two-wire control circuit. Closing the S1 contact initiates a start by applying power to the motor; opening the S1 contact causes the starter to initiate a stop (or soft-stop, if so configured).
- Once full voltage is applied to the motor, the starter closes the bypass contactor.
- Trip states may be reset, and fault indication cleared, by operating the remotely-located Reset pushbutton or removing control voltage from the starter.

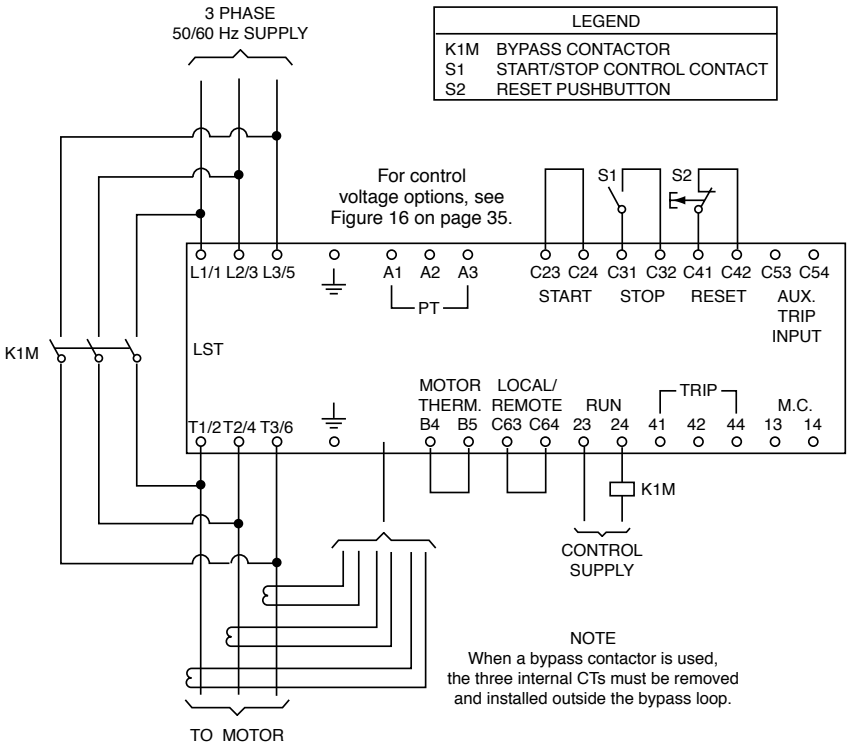

Figure 19: Wiring Connections for Sample Application 3

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5.6.4 Sample Application 4

In this sample application, the LST starter is installed with an undercurrent protection relay and motor operation is controlled via a remote two-wire signal. Figure 20 shows the wiring connections for this sample application.

Installation procedure:

1. Connect line voltage to the LST starter's terminals (L1/1, L2/3, L3/5).
2. Connect the motor to the starter's output terminals (T1/2, T2/4, T3/6).
3. Connect the control voltage to the starter's PT input (control power) terminals; see Figure 16 on page 35.
4. Connect control circuitry as shown in Figure 20.
5. The performance of the LST starter may be adjusted using the DIP switch. See page 47 for configuring the DIP switch and page 49 for fine-tuning the performance of the starter.

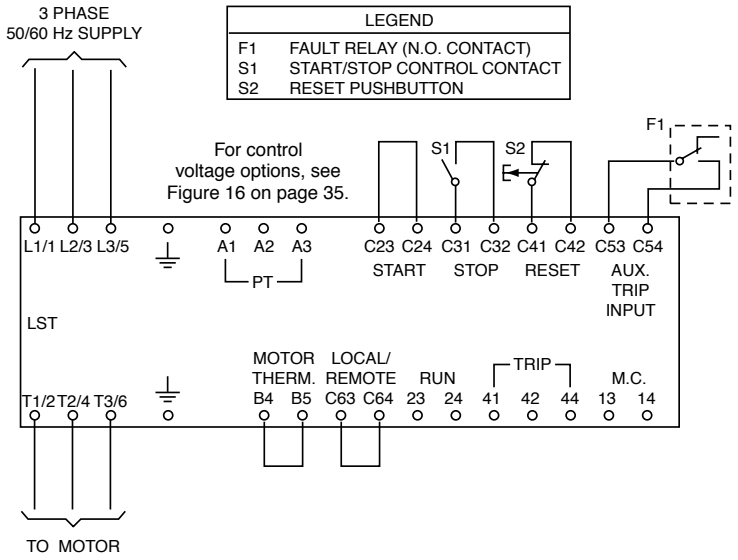

Figure 20: Wiring Connections for Sample Application 4

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Notes:

- The motor may be started and stopped via the remote two-wire control circuit. Closing the S1 contact initiates a start by applying power to the motor; opening the S1 contact causes the starter to initiate a stop (or soft-stop, if so configured).
- Operation of the undercurrent relay will cause the starter to trip and show the Auxiliary Trip indication.
- Trip states may be reset, and fault indication cleared, by operating the remotely-located Reset pushbutton or removing control voltage from the starter.

5.7 Final Assembly

After making the desired power and control wiring connections, locate the cover and attach it to the front of the enclosure extension using the two screws provided.

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NOTES

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Section 6: First Time Power-Up

⚠ DANGER

HAZARDOUS VOLTAGE

Before servicing the electrical system:

- Read and understand this manual before installing or operating the LST Solid-State Starter. Installation, adjustment, repair, and maintenance of this starter must be performed by qualified personnel and in accordance with good electrical practice. Do not operate this equipment in a manner other than as detailed in this manual.
- For advice on operating this equipment, contact a TB Wood's Electronics Application Engineer at 1-888-829-6637.
- Disconnect all power. Measure L1/1-L2/3, L2/3-L3/5, and L3/5-L1/1 to ensure no AC voltage is present.
- Ensure that the LST Solid-State Starter is completely isolated from the power supply before attempting any work on the unit.
- Ensure that the cabinet is free of metal shavings and other debris.
- Do not apply voltage to the starter's digital input terminals. These are active 12/24 Vdc inputs and must be controlled with hard contacts only.
- Do not connect power factor correction capacitors to the LST Solid-State Starter's output. If static power factor correction is used, it must be connected to the supply side of the starter.
- If installing the LST Solid-State Starter within a non-ventilated enclosure, use a bypass contactor to prevent excessive heat build up.
- If installing a bypass contactor, ensure that phase connections are correctly made (through the contactor) between L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6.

Failure to observe these instructions will result in death, serious injury, or equipment damage.

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⚠ DANGER

TENSION DANGEREUSE

Avant d'entretenir le système électrique:

- Lisez et comprenez ce manuel avant d'installer et de faire fonctionner le démarreur transistorisé LST. L'installation, les réglages, la réparation et l'entretien du démarreur doivent être effectués par du personnel qualifié en conformité avec les bonnes règles de l'art en électricité. Ne faites pas fonctionner cet appareil d'une façon autre que celle indiquée au manuel.
- Pour des conseils sur le fonctionnement de cet appareil, communiquez avec l'ingénieur d'applications électroniques de TB Wood au 1-888-829-6637.
- Coupez toute alimentation. Mesurez entre L1/1-L2/3, L2/3-L3/5 et L3/5-L1/1 pour vous assurer qu'il n'y a pas de tension ca.
- Assurez-vous que le démarreur transistorisé LST est totalement isolé de l'alimentation ayant d'y travailler.
- Assurez-vous que l'armoire ne contient pas d'ébarbures ni d'autres débris.
- N'appliquez pas la tension aux bornes d'entrée numérique du démarreur. Ce sont des entrées actives à 12/24 Vcc qui doivent être commandées par des contacts secs seulement.
- Ne raccordez pas les condensateurs de correction du facteur de puissance à la sortie du démarreur transistorisé LST. Lorsque la correction statique du facteur de puissance est utilisée, elle doit être reliée au côté alimentation du démarreur.
- Si vous installez un démarreur transistorisé LST dans une armoire non-ventilée, utilisez un contacteur de dérivation pour éviter l'accumulation de chaleur excessive.
- Si vous installez un contacteur de dérivation, assurez-vous que les raccordements de phase sont adéquats (passant par le contacteur) entre L1/1 et T1/2, L2/3 et T2/4, L3/5 et T3/6.

Si ces précautions ne sont pas respectées, cela peut entraîner la mort, des blessures graves ou des dommages matériels.

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6.1 Start-Up Checks

Before operating the LST starter, perform the following start-up checks:

1. Ensure that the correct model has been supplied as ordered for your application.
2. Inspect the starter and report any visible signs of damage to TB Wood's.
3. Verify that the control circuit is suitable for the application and compatible with the starter.
4. For long-term reliability of the product and for the elimination of overtemperature trips, it is important that the starter be properly cooled. Ensure that the ventilation is appropriate for the application. See Figure 7 on page 20 for minimum clearances.

   If you remove the enclosure extension and mount the starter in another enclosure without an SCR bypass contactor, ensure that sufficient air circulates through the enclosure to cool the starter. This may require forced ventilation of the enclosure. See Table 7 on page 21 for minimum airflow requirements.
5. Ensure that the electronics and fan PT input (control power) is connected to a control supply. Use either terminals A1 and A2 (for 115 V) or A2 and A3 (for 230 V). **Use only two terminals.**
6. Following the starter adjustment procedures given in Section 7 of this manual, set the starter for the desired parameters.

6.2 Commissioning Check Procedure

To place the LST starter in operation, perform the following checks and procedures:

1. Ensure that the main supply disconnect is **open** and that no voltage is being delivered to the starter.
2. Ensure that the enclosure is free of metallic shavings, wire scraps, or other debris.
3. Before connecting the output terminals to the motor, perform an insulation test of the motor windings to earth. The reading should be in excess of 10 MΩ. If practical, an insulation test between windings should also be performed.
4. Connect the output terminals to the motor.
5. Ensure that all the main power terminations are tight.

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6. Ensure that the voltage applied to the disconnect is correct and that all three phases are present.
7. Ensure that the incoming supply is connected to L1/1, L2/3, and L3/5.
8. If the starter is installed with a bypass contactor, ensure that the contactor is bypassing the appropriate terminals on the starter: L1/1 must connect via the bypass contactor to T1/2, L2/3 must connect via the contactor to T2/4, and L3/5 must connect via the contactor to T3/6. If the starter is incorrectly bypassed, damage to the starter can result, and supply fuses will fail or the circuit breaker will open.
9. If the starter is installed with a bypass contactor, check that the internal CTs were re-mounted in the enclosure extension, and are monitoring line current. See Appendix A on page 61 for more information.
10. Apply the control supply to the starter, and ensure that all fans are running freely and that the Power LED is illuminated.
11. Check the status of all digital inputs by measuring the voltage across them. The Stop and Reset inputs should show zero volts if closed. If two-wire control is used, the Stop input should be open and have a terminal voltage of between 12 and 24 Vdc.
12. Connect an ammeter in the circuit to display the current during start. Use a sufficiently-rated clamp type meter.
13. Ensure that the motor, couplings, and machine are ready for an attempted start.
14. Start the motor using the LST starter and monitor the start current and direction of rotation. If the direction of rotation is incorrect, stop the machine, isolate the starter (that is, open the disconnect), and swap two phases on the input or the output of the starter.
15. Ensure that the measured start current does not exceed the ratings for the LST Solid-State Starter.
16. If a bypass contactor is used, ensure that it closes once the motor has reached full speed and the start current has dropped.
17. Ensure that the motor and machine operate satisfactorily.

After completing the Commissioning Check Procedure, record the settings and file them in an appropriate location for future reference.

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Section 7: LST Starter Configuration

7.1 Introduction

The LST Solid-State Starter is configured via the DIP switch located beneath the cover on the front of the starter. For nearly all applications, setting the DIP switch as directed in this section should produce satisfying performance. However, if further refinement is required, potentiometers are available for fine-tuning the starter's performance. These potentiometers are also discussed in this section.

7.2 DIP Switch Configuration

The DIP switch is located beneath the cover on the front of the LST starter as shown in Figure 21 below. The following sections describe the four items configured by the DIP switch.

7.2.1 Soft-Stop Ramp Time

If you wish to employ a soft-stop, set the top five switches to add up to the required ramp time. If you do not wish to utilize a soft-stop, set all switches to zero.

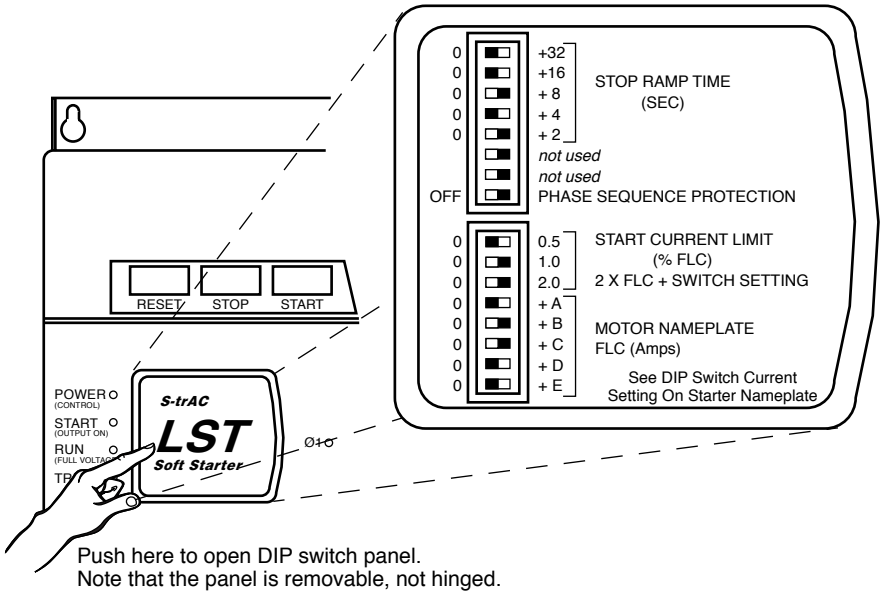

Figure 21: Location of DIP Switch

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You should set the stop time to optimize stopping conditions for the connected load. Note, however, that the set time does not dictate the actual stopping time of the motor, which is dependent on motor and load characteristics. The soft-stop ramp merely specifies the time in which the applied voltage will be reduced to zero and the motor is offline.

7.2.2 Phase Sequence Protection

Phase sequence protection guards against reverse motor rotation due to changes in the phase sequence of the incoming supply. If you wish to use this type of protection, set the DIP switch to the On position. Note that if reversing contactors are part of the application, you should not use phase sequence protection (the DIP switch should be set to Off).

7.2.3 Start Current

The top three switches of the lower group are used to configure the Initial Start Current as a percentage of FLC. The start current is the initial current from which the current ramps up to the current limit, as shown in Figure 5 on page 17.

You should set the Initial Start Current such that the motor easily accelerates to full speed. The minimum start current is two times FLC, which is configured by setting all three switches to zero. To set the start current to a different level, set the switches so they add up to the desired current when added to twice the FLC value. In other words:

Start Current = Switch 1 Value + Switch 2 Value + Switch 3 Value + (2 x FLC)

While the maximum value for the Initial Start Current is 5.5 times FLC, care should be taken to not exceed the LST starter's ratings as detailed on the rating nameplate.

Note that the initial start current may be fine-tuned by using the Initial Start Current potentiometer; see page 48 for further information.

7.2.4 Motor Nameplate FLC

The bottom five switches of the lower group are used to configure the FLC value as obtained from the connected motor's nameplate. You should set the five switches so that they add up to the FLC value. However, the value assigned to each of the letters is different for each LST starter model. Table 13 on the next page shows the value (in amps) for each of the letters for each LST model.

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Table 13: Switch Values for Setting Motor Nameplate FLC

LST Model	Value (in amps) of Switch Labeled:				
	A	B	C	D	E
LST90130B	1	2	4	8	16
LST90250B	2	4	8	16	32
LST90340B LST90390B LST90550B	3	6	12	24	48
LST90730B LST90800B	4	8	16	32	64
LST91260B LST91360B LST91580B	8	16	32	64	128
LST91930B	12	24	48	96	192
LST92230B LST92640B	16	32	64	128	256
LST93720B	20	40	80	160	320

7.3 Customizing LST Starter Performance

For nearly all applications, setting the DIP switch to the appropriate values will produce satisfactory performance. However, if further refinement is desired, five potentiometers are available for customizing the performance of the LST starter. These potentiometers allow you to:

- Modify the soft-start characteristics by adjusting the ramp time and initial start current.
- Adjust the sensitivity of the motor overload, electronic shearpin, and phase loss protective features.

7.3.1 Accessing the Potentiometers

To access the potentiometers, you must remove the cover of the LST starter. Follow these steps to accomplish this:

1. Disconnect all power from the LST starter.
2. If necessary, remove the two screws securing the cover of the enclosure extension.
3. Remove the four screws securing the cover of the starter.

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4. Carefully lift the cover. Do not lift too far or with too great a force as you may damage the loom connections.
5. The five potentiometers are located on the circuit board on the underside of the cover. Figure 22 below shows a representation of their location on the circuit board. Adjust the desired potentiometer(s) as directed in the next section.
6. After adjusting the potentiometer(s), reverse these steps to re-assemble the LST starter. Exercise care to not damage the loom connections or wiring.

7.3.2 Adjusting the Potentiometers

After accessing the potentiometers, use an insulated screwdriver to turn the potentiometers in the desired direction. If you turn any of the potentiometers in a clockwise direction, you will increase the ramp time, Initial Start Current, or sensitivity. Conversely, if you turn a potentiometer in a counterclockwise direction, you will decrease the ramp time, Initial Start Current, or sensitivity.

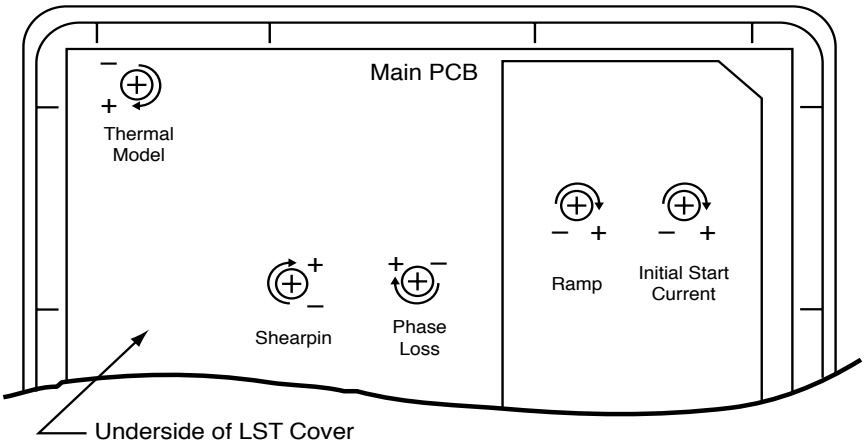

Figure 22: Location of Potentiometers

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Section 8: Troubleshooting

⚠ DANGER

HAZARDOUS VOLTAGE

- Read this manual in its entirety before connecting and commissioning this equipment.
- Troubleshooting and repair of this equipment must be performed only by qualified personnel.
- Ensure that the LST Solid-State Starter is completely isolated from the power supply before attempting any work on the unit.

Failure to observe these instructions will result in death or serious injury.

⚠ DANGER

TENSION DANGEREUSE

- Lisez tout ce manuel avant de raccorder ou de mettre en service cet appareil.
- Seul du personnel qualifié doit faire le dépannage et la réparation de cet appareil.
- Assurez-vous que le démarreur transistorisé LST est totalement isolé de l'alimentation avant d'y travailler.

Si cette directive n'est pas respectée, cela entraînera la mort ou des blessures graves.

8.1 Introduction

Abnormal conditions are generally indicated by the LEDs for starter status on the front of the LST starter (see Figure 3 on page 11). This section approaches troubleshooting by providing tables based on the condition of the status LEDs and the phase LEDs. In addition, more generalized abnormal conditions are also discussed.

8.2 Conditions Indicated by Status LEDs

If the Trip LED on the front of the starter is flashing (which indicates that the starter has tripped due to a fault condition), also check the status of the three-phase LED indicators.

If the three LEDs are not all illuminated, or if they do not glow with equal brilliance, see Table 14 on page 52. On the other hand, if the three LEDs are all illuminated with equal brilliance, see Table 15 on page 53. (Note that when the phase LEDs are illuminated equally, the Trip LED will flash multiple times rapidly, then remain extinguished for a short

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period, and then repeat this sequence to indicate the particular fault that caused the trip condition.)

If the Power LED is not illuminated, see Table 16 on page 55.

Table 14: Trip LED Flashing and All Phase LEDs Not Illuminated Equally

Possible Cause	Action
Invalid motor connection	• With voltage applied to the input of the starter, check the voltage (input to output) of each phase of the starter. If the voltage measured on the phase which has the dim or extinguished LED is zero, low, or not equal to the other phases, this indicates the potential for an incorrect motor connection. • Verify the motor connection (see page 25).
Missing phase(s)	• With voltage applied to the input of the starter, check the voltage, input to output, of each phase of the starter. If the voltage measured on the phase which has the dim or extinguished LED is zero, low, or not equal to the other phases, this indicates the potential for an incorrect motor connection. • Ensure that three phases are present at the input terminals. • Ensure that the motor is correctly connected to the starter. • Ensure that each winding of the motor is continuous. • Verify each circuit between the starter and motor.
Failed SCR	• With voltage applied to the input of the starter, check the voltage (input to output) of each phase of the starter. If the voltage measured on the phase which has the dim or extinguished LED is zero, low, or not equal to the other phases, this indicates the potential for a failed SCR. • Disconnect the supply and motor. Then, use a 500 V analog insulated tester (low-voltage ohm meters or multi-meters are not adequate), measure the resistance between input and output on each phase (L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6). This resistance should be close to 33 kΩ. If less than 33 kΩ, then excess leakage through the SCRs may be occurring. If greater than 33 kΩ, then a control PCB fault or a Firing Loom fault may have occurred.

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Table 15: Trip LED Flashing and All Phase LEDs Illuminated Equally

Possible Cause	Action
Invalid phase sequence	• If phase sequence protection is not required, ensure that the phase sequence protection switch is set to Off (see page 48) and retry. It may be necessary to reverse the incoming phase sequence if phase sequence protection is required.
Frequency out of range (Trip LED flashes once if starter is not running or five times if it is running when trip occurs)	• Check the supply frequency; it should be 50 Hz ± 2 Hz or 60 Hz ± 2 Hz. • If the supply frequency is okay, the likely cause is the loss of three-phase input while the motor was running or the genset governor (portable generator) is out of calibration.
Overcurrent Trip (Trip LED flashes twice)	The starter monitors the current drawn by the motor and mathematically models the expected motor temperature. The starter will not allow a restart after an overcurrent trip until the thermal model has reached a temperature below the trip temperature. Note that the motor must be allowed to cool sufficiently for a hot restart to occur. If the thermal margin is small, the motor may only achieve partial speed before re-tripping. • Check the motor and load for the cause of the motor overload. Allow time for the motor to cool, and then reset and restart. • Check that the DIP switch is set correctly for the attached motor's FLC value (see page 48 for information on setting the DIP switch). • Check that the DIP switch setting for the initial start current is adequate to allow the motor to easily accelerate to full speed (see page 48 for information on setting the DIP switch). • If an overcurrent trip occurs during acceleration and the motor was cold at the start, adjust the Thermal Model potentiometer to decrease the sensitivity (see page 49 for more information).
Thermistor Trip (Trip LED flashes three times)	The starter monitors the thermistor circuit attached to terminals B4 and B5. It will trip (or not re-start) if a thermistor fault is present. • Check the condition of the motor. If it is hot, the thermistors are probably operating correctly (shutting down when too hot). Wait for the motor to cool, and then reset and restart. • Check that a connection is made to terminals B4 and B5. If a thermistor circuit is not used, a jumper must be connected across these two terminals. • Check the thermistor circuit for continuity.

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Table 15: Trip LED Flashing and All Phase LEDs Illuminated Equally

Possible Cause	Action
Phase Imbalance Trip (Trip LED flashes four times)	The starter monitors the current drawn on each phase and calculates the difference between the currents flowing on the three phases. The difference between the highest phase and the lowest phase is compared and a trip will occur if a continuous condition exceeds the preset limits. • Ensure that all three phases are present at the starter's input. Measure phase-to-phase and phase-to-neutral for each phase. • Ensure that the circuit from the starter to the motor is complete. • Disconnect the starter from the supply. Check for circuit continuity by measuring between each output phase with an ohmmeter. The reading is generally 1 to 2 Ω.
Electronic Shearpin Trip (Trip LED flashes six times)	The starter monitors the current drawn by the motor and trips if the shearpin limit is exceeded. • Ensure that the motor is not severely overloaded. If it is overloaded, reduce the load, reset, and re-start. • See if the load is jammed. If so, unjam the load, reset, and re-start. • Check whether a power factor correction is connected to a starter's output terminal. If so, correct the condition.
Auxiliary Trip (Trip LED flashes seven times)	• Discover why the Auxiliary Trip was activated and correct the condition. Reset and restart. • Check the Auxiliary Trip circuit for continuity.

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Table 16: Power LED Not Illuminated

Possible Cause	Action
Incorrect control voltage	• Ensure that the control voltage is present and correctly connected to the transformer inputs (A1 and A2 for 115 V ***or*** A2 and A3 for 230 V). This can be easily checked using an AC volt meter and measuring the voltages at the terminals. Voltages should correspond to those listed on the starter's nameplate.
Transformer failure	• The integrity of the starter's PT input (control power) can be checked by measuring the secondary voltage of the transformer. Remove the starter's cover to reveal the PT and unplug the white plug from the Main Control PCB. After confirming the correct voltage is applied to the input of the transformer, measure the AC voltage coming from the transformer. It should be 18 Vac (±4 V) between the two orange leads, and 9 Vac (±2 V) between the purple lead and each of the orange leads.
Control fuse failure	• Ensure that all fuses in the control and power circuits are intact. Fuse information is provided on page 24.

8.3 Abnormal Motor Performance

This section addresses the conditions where the motor behaves in an unexpected manner. The following conditions are addressed:

- The motor will not start; see Table 17 below.
- A DOL or uncontrolled start occurs; see Table 18.
- The motor starts, but behaves differently than expected; see Table 19 on page 57.

Table 17: Motor Will Not Start

Possible Cause	Action
Incorrect control voltage	• Ensure that the control voltage is present and correctly connected to the transformer inputs (A1 and A2 for 115 V ***or*** A2 and A3 for 230 V). This can be easily checked using an AC volt meter and measuring the voltages at the terminals. Voltages should correspond to those listed on the starter's nameplate.
Control circuit fault	• Check the Control Input LEDs on the front of the starter and ensure that they indicate the expected circuit status. The Stop and Reset circuits must be closed before the starter will accept a start input. • The status of the control inputs may be independently verified using a volt meter to measure across the terminals. If 24 Vdc is measured across either of the terminals when a Start is called for, the switch/control is connected incorrectly or is faulty.

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Table 18: DOL or Uncontrolled Start

Possible Cause	Action
Incorrectly installed power factor correction capacitors	• Power factor correction (PFC) capacitors, if used, must be connected to an input terminal of the LST starter or damage may result. Ensure that PFC capacitors are not connected to the output terminals of the starter. If a PFC capacitor is connected to the output, disconnect it and re-connect it to an input terminal.
CTs not connected	• For all LST models except the three largest models, if the starter is bypassed during Run, the CTs must be removed from their internal position and mounted in the enclosure extension to preserve protective features. Check that the CTs were positioned correctly so that they would monitor the current from either the LST or the bypass contactor. • For the three largest LST models, the CTs are already correctly positioned in the enclosure extension and so should not cause a DOL or uncontrolled start.
Damaged SCRs or firing circuit	To test for a damaged SCR, perform the Resistance Test to verify the Off state resistance of the thyristors. If the power section of a thyristor fails, it usually fails due to a short-circuit. The Resistance Test is as follows: • For an installation with an earthed neutral, apply three-phase input power to the starter in the Off state and then measure the voltage between the outputs and neutral (or earth). This should be less than 10 Vac. • For an installation with no neutral, apply three-phase input power to the starter in the Off state and then measure the voltage from input to output on each phase (L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6). This measured voltages should be roughly equal. To test the firing circuit, perform the Firing Circuit Test. This test verifies the proper firing of the thyristor gate circuits and check the entire firing circuit including SCR, Firing Loom, and circuit board. The Firing Circuit Test is as follows: • Ensure that the Firing Looms are plugged into the main PCB. • Disconnect the supply and motor. • Use a 500 V analog insulated tester (low-voltage ohm meters or multi-meters are not adequate), measure the resistance between input and output on each phase (L1/1 to T1/2, L2/3 to T2/4, and L3/5 to T3/6). This resistance should be close to 33 kΩ. If less than 33 kΩ, then excess leakage through the SCRs may be occurring. If greater than 33 kΩ, then a control PCB fault or a Firing Loom fault may have occurred. • To discriminate between a PCB fault and a Firing Loom fault, swap the Firing Loom plug from the phase with the high resistance with a plug from one of the other phases. Then repeat the resistance measurements. If the high resistance remains on the same phase, the Firing Loom is suspect (and should be checked for loose connections or replaced). If the high resistance moves to a new phase, then the PCB may be at fault and should be replaced.

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Table 19: Motor Does Not Behave As Expected

Symptom	Action
Motor does not breakaway or accelerate to full speed	This may result from improperly-set Start Current Limit. • If the motor and load have previously successfully reached full speed, but now cannot, determine why the starting torque requirements have increased. Correct as necessary. • Increase the DIP switch setting for the Start Current Limit (see page 48) so that the motor can produce sufficient torque to accelerate the load to full speed.
Motor does not rotate immediately when a Start is called for	The LST starter's start ramp requires about five seconds to reach the user-set initial start current when a Start is initiated. This delay, while negligible for most applications, may cause some loads to not rotate immediately. If this is a problem for your application, perform the following: • Increase the DIP switch setting for the initial start current; see page 48 for information on setting the DIP switch. • Reduce the length of the ramp time by adjusting the Ramp Time potentiometer; see page 49 for further information.
Erratic motor operation and tripping	• Where very small motors are used to test the operation of large starters, the possibility exists that drawn current may be insufficient to latch the starter's thyristors. Remedy this situation by increasing the motor size or loading.
Soft-Stop does not function	• The soft-stop function is not able to work if the start/stop circuit opens the contactor when a Stop is called for. Correct the stop circuit; see Sample Application 2 on page 37 for guidance. • Ensure that the DIP switch setting for the Soft-Stop Ramp Time is set correctly. If all switches are set to zero, a soft-stop will not occur. See page 47 for information on setting the DIP switch.

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Section 9: Warranty Information

9.1 Hassle-Free Warranty

The driving force at TB Wood's is customer service, including dealing with unforeseen problems without creating new ones! TB Wood's takes the extra step to ensure that ANY problem that occurs to its electronic products is dealt with swiftly and with no hassles to you. The Hassle-Free Warranty removes the "burden of guilt" and promises to quickly repair any failed product.

TB Wood's Incorporated warrants the LST Solid-State Starter to be free of defects in parts or workmanship for a period of one year from the date of manufacture. If a LST starter fails for any reason, excluding physical abuse or repeated failure, within the warranty period, TB Wood's will promptly repair the starter. TB Wood's Incorporated shall not in any event be liable for any incidental or consequential damages, secondary charges, expenses for installing or disconnecting, or losses to persons or property resulting from any failure of the LST Solid-State Starter.

9.2 Procedure for Repairs

If a LST Solid-State Starter needs to be returned for repair, you must first obtain an RGA number before returning the unit. To obtain an RGA number, call 1-888-TBWOODS (829-6637).

After obtaining the RGA number, create a packing list for the LST starter to be returned for repair. This packing list should be on your company's letterhead and should state, at a minimum, the model number, serial number, and RGA number.

After creating the packing list, send the LST starter and packing list to the following address:

TB Wood's Incorporated
100 Bonita Drive
Greensboro, NC 27405

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NOTES

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Appendix A: Repositioning CTs for Bypass Operation

When an LST Solid-State Starter is mounted in a non-ventilated enclosure, a bypass contactor should be used to eliminate heat buildup in the enclosure. The use of a bypass contactor will also require that the current transformers (CTs) be mounted in the enclosure extension rather than inside the starter itself to preserve the protective features of the LST starter. This Appendix explains how to remove and re-mount the internal CTs.

Note that since the CTs are already mounted in the enclosure extension for the three largest LST models (LST92230B, LST92640B, and LST93720B), this procedure does not apply to these models. For bypassed operation with these models, the CTs may be connected on either the line or motor side. However, be sure that the CTs are outside the bypass loop. Figure 23 shows the connection diagrams for the CTs.

Also note that you do not need to reposition the CTs if separate motor protection is provided while the LST starter is bypassed.

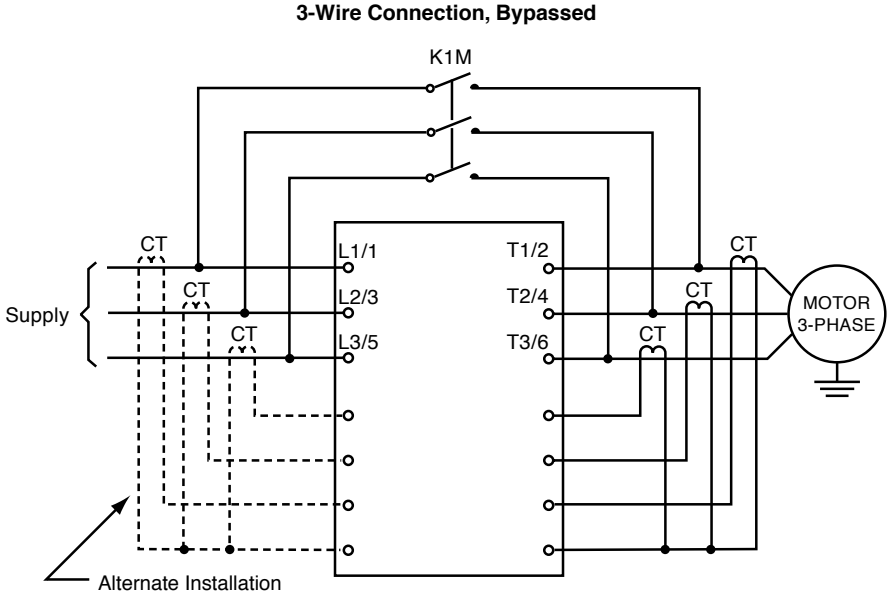

Figure 23: Wiring Connections for Current Transformers (CTs)

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⚠ DANGER

HAZARDOUS VOLTAGE

Disconnect all power before servicing the electrical system.

Failure to observe this instruction will result in death or serious injury.

⚠ DANGER

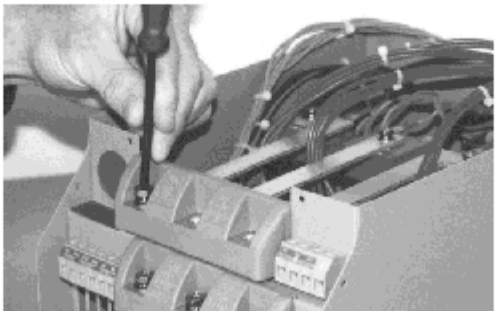
TENSION DANGEREUSE

Coupez toute source d'alimentation avant d'entretenir le système électrique.

Si cette directive n'est pas respectée, cela entraînera la mort ou des blessures graves.

To reposition the CTs, follow these steps:

1. Obtain "External Mount CT Wiring Loom" (part number 9FLCE1) from TB Woods.
2. Once the necessary part is obtained, disconnect all power from the LST starter.
3. Remove the two screws securing the cover of the enclosure extension, and then remove the cover and set aside.
4. Unscrew the four screws securing the cover of the starter.
5. Lift the cover only enough to reach the wiring loom connections beneath the cover. Do not lift too far or too forcefully as you may damage the wiring loom or connections.
6. Unplug all loom connections, and then set the cover aside.
7. Remove the three screws from the input terminals, as shown below (note that in this picture, and all subsequent pictures, the enclosure extension was removed for clarity):



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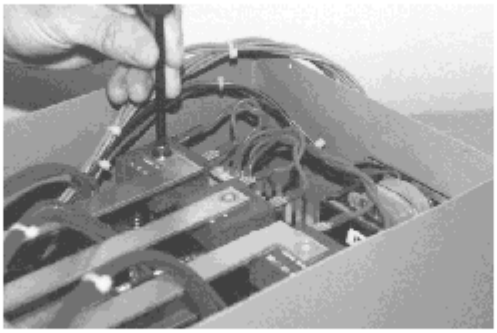
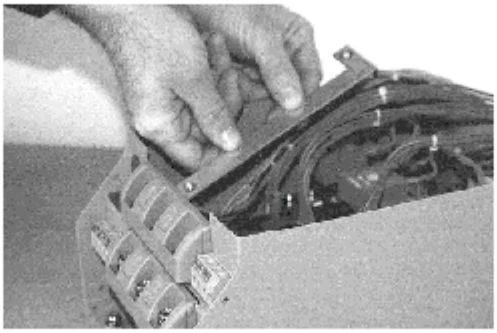
8. Remove the three input bus bars running from the input terminal block molding to the CTs by removing all six screws retaining the bus bars and then sliding the bars out of the molding. The pictures below illustrate this step.





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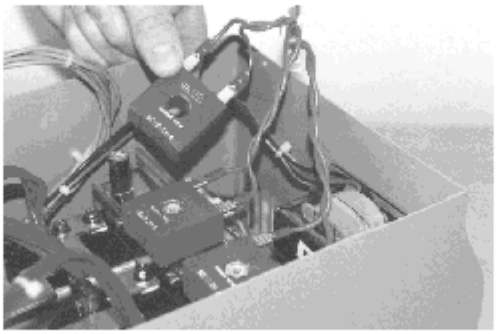
9. Remove the CTs by unplugging the white six-way connector from the CT shunt PCB and lifting the CTs out of the unit.



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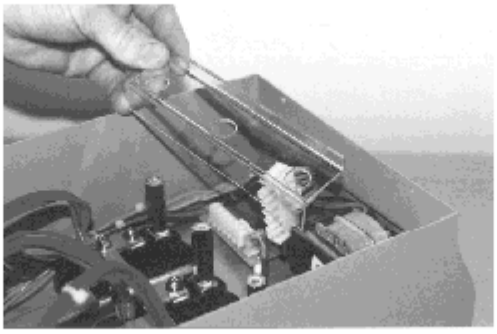
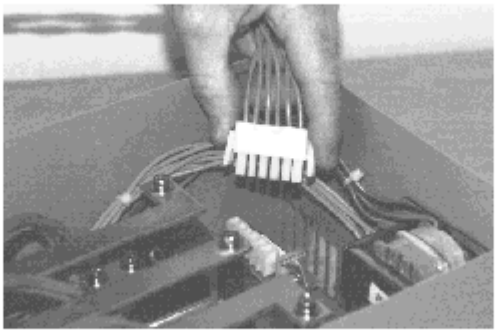
10. For models LST90130B through LST90390B, discard the CT mounting bracket. For models LST90550B through LST91360B, leave the CT mounting bracket in place. For models LST91580B through LST93720B, this is not applicable. The CT mounting bracket is shown in the picture below.



11. Replace the three input bus bars removed in step 8 on page 63 by reversing the procedure used to remove them.
12. Install the "External Mount CT Wiring Loom" by plugging its six-way wiring connector into the CT shunt PCB, as shown in the picture below.



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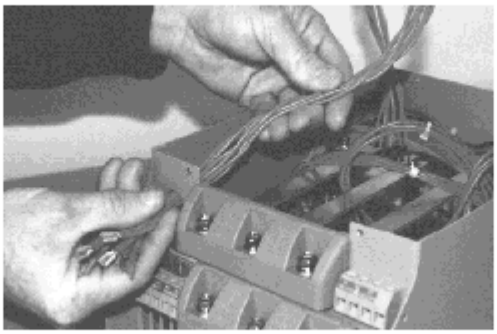
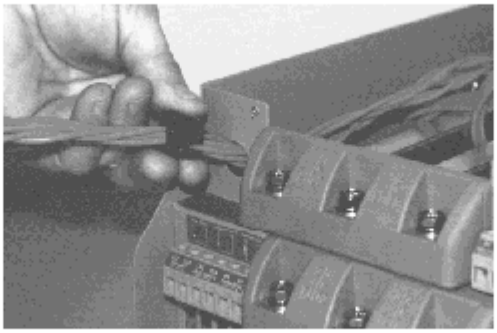
13. Feed the loose ends of the "External Mount CT Wiring Loom" through the case of the LST starter and secure with the cable gland supplied, as shown below.





14. Re-connect the wiring loom to the cover and replace the cover to the LST starter as described in steps 3 through 4 on page 62. Exercise care so that no wiring is pinched or connectors damaged.
15. Remove the short, orange CT wiring loom from the CTs that were removed from the starter.

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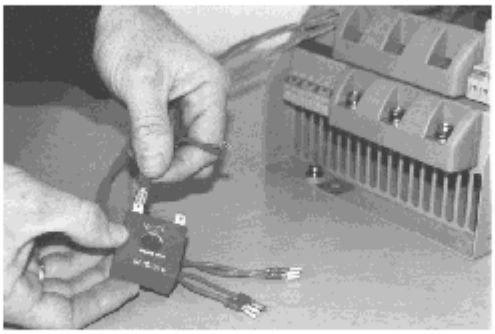
16. Connect the loose ends of the "External Mount CT Wiring Loom" to the three CTs, as shown in the picture below.



17. Mount the CTs to measure line current, as shown in the picture below.

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N O T E S

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Appendix B: Removal of the Enclosure Extension

The LST Solid-State Starter provides NEMA 1/IP23 protection as standard. This is achieved by utilizing an enclosure extension that encloses the wiring connections and makes them finger-safe.

If desired, the enclosure extension may be removed, resulting in IP00 protection and making the LST starter suitable for mounting in an enclosure. Figure 24 below shows how the enclosure extension fits together. Figures 25 and 26 on the next two pages provide the dimensions of the LST starter without the enclosure extension.

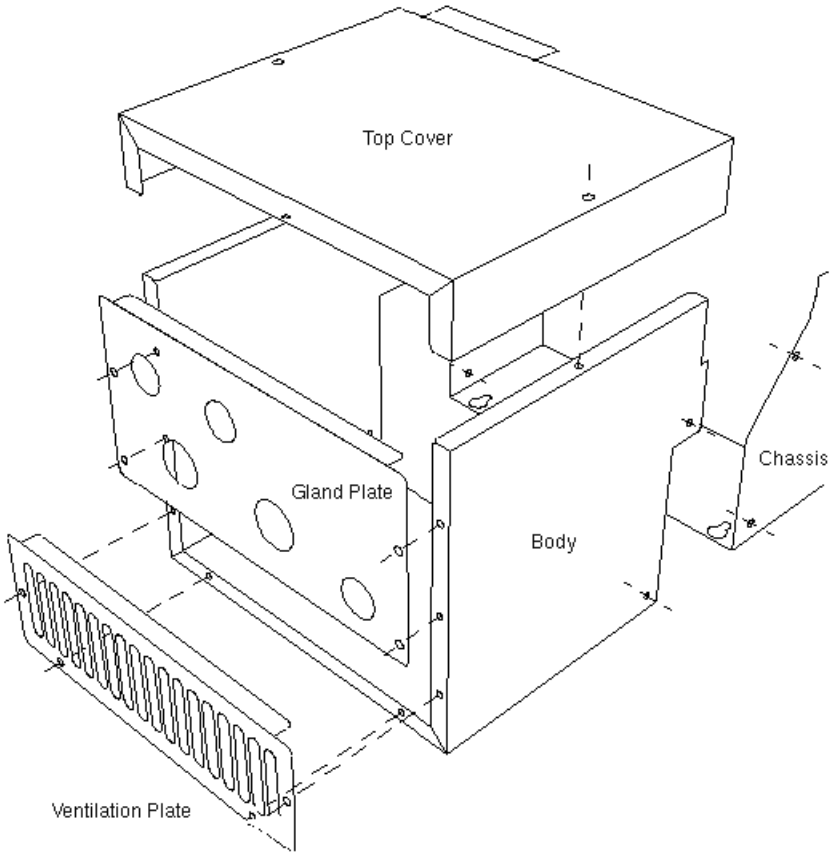

Figure 24: The LST Starter Enclosure Extension

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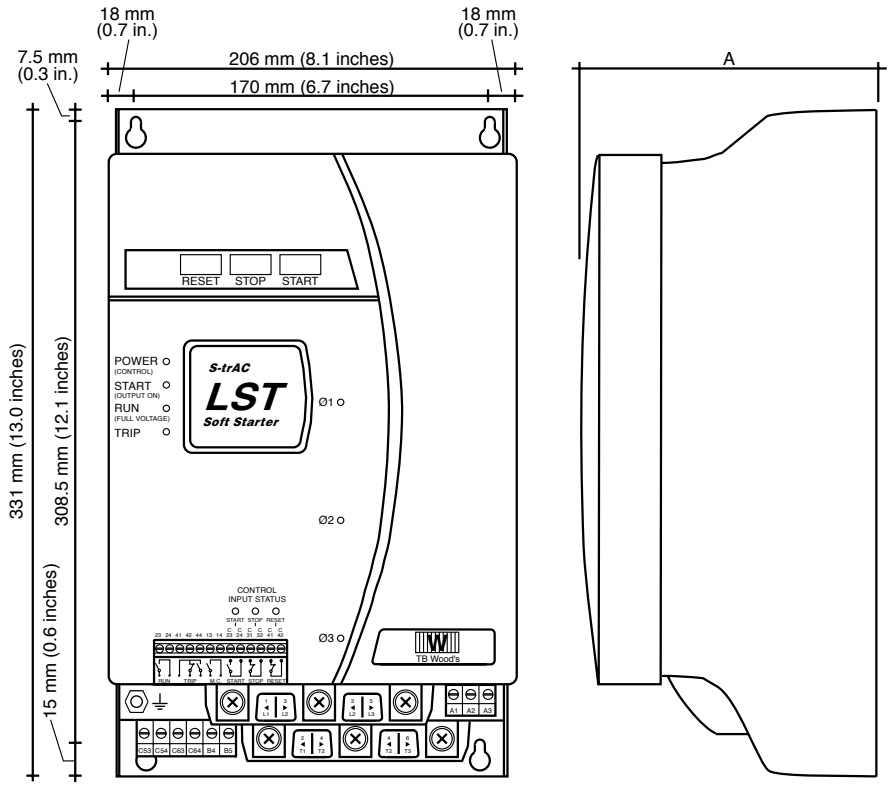
Appendix B: Removal of Enclosure Extension



LST Model	Dimension "A" mm (inches)
LST90130B, LST90250B, LST90340B, LST90390B	180 (7.1)
LST90550B, LST90730B, LST90800B, LST91260B, LST91360B	250 (9.8)

Figure 25: LST Models Rated 136 Amps or Less

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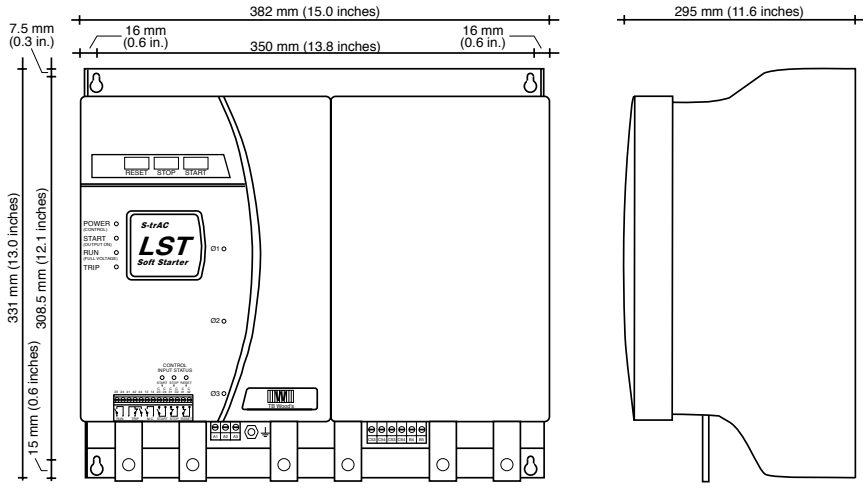

Figure 26: LST Models Rated 158 Amps or Greater

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